Research on Housing Planning Development Design in Mountainous Area: Difference between China and Hawaii

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Abstract

With the rapid development of urbanization in China, more and more houses are being put up; however, the land resources available are quite limited. As a result, the problem of residential development has become a contradiction between man and land. Owing to the feature of this development situation, and the fact that the majority of land resources are in the form of mountains or hills, people have to consider how to develop mountainous areas to increase the living space. However, in the process of building mountainous residential buildings, the protection of land and environmental resources is often neglected due to the pursuit of the maximization of commodity interests and the large demolition and construction of land resources in mountainous areas, which result in the loss of land resources and the occurrence of various consequent natural disasters.

Therefore, the author of this dissertation takes the opportunity of this dual-degree training program between Tongji University and the University of Hawaii, compares the similarities and differences of the development of residential house between China and Hawaii, and draws vantages and advantages from mountainous or hillside residential development in Hawaii to explore how to solve and improve the development of China's domestic mountainous residential houses and the contradiction between man and land to provide guidance for the sustainable construction of new rural housing in mountainous areas by examining the characteristics and ideas of mountainous and hillside houses of development in Hawaii.

This present thesis is divided into eight chapters. Chapter One serves as the introduction, which mainly introduces the background, purpose and significance of the research. Chapter Two presents the related theoretical research, which mainly discusses related domestic and foreign theoretical research on the use and development of mountainous areas and mountain cities from all ages, and makes a

detailed introduction to the contents of theoretical research based on the theories of mountainous residential settlements. Chapter Three, the Historical Development of the Mountainous Residences in Hawaii and Mainland China, focuses on and compares the characteristics of the historical development of the mountainous residential areas and the historical process of the use of mountainous areas in the United States and China, and compares the differences between the two regions through the perspectives of residential layout model, courtyard and public space as well as road development, and concludes that there is a fundamental similarity between them, namely, mountainous areas were by no means easy to reach before there emerged powered means of transport. Chapter Four, the Modern Planning Development of the Mountainous Residences in Hawaii and the Development of Domestic Modern Mountainous Residences, focuses on and compares the planning characteristics and mountain utilization features in the development of modern mountainous residential areas in Hawaii, the United States and in China to find out the differences and draw the surface similarities in the use of cluster layout model in mountainous areas by means of progressive land use mechanism and planned construction modes. Chapter Five, a Comparison of the Design Norms for Mountain Residential Buildings in Hawaii and in China, mainly studies the classification as well as planning and designing norms of the residential lands in Hawaii and China, summarizes several typical directions to compare their difference and reaches the conclusion that China can learn and benefit from some norms in Hawaii. Chapter Six, A Case Study of the Practices and Characteristics of Sloping Land and Mountainous Residences in Oahu Region, Hawaii, summarizes the characteristics and features of the planning and construction of the two categories of mountainous and hillside residential areas in Hawaii. Chapter Seven, the Planning and Design of Mountainous Residential Buildings in FengGang

Township, completes the design of renewal, mainly targeted at Mainland China's current mountainous residential situation to provide innovative tips and renewal programs for the planning and design of China's mountainous and hillside residential areas. Chapter Eight, Conclusion and Prospects, puts forward three guiding opinions for the sustainable development planning model of the new type of mountainous and hillside residences in China, looking forward to further and more detailed research in the future.

The whole thesis illustrates the author's reflections on the comparison of mountainous and hillside residential buildings between Hawaii and Mainland China and the consequent conclusions. Due to the limit of time and the limited vision of the author, there is still some room to be desired.

Keywords: Mountain Residence, Planning Design, Sustainability

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CONTENTS

CHAPTER 1 | INTRODUCTION

1.1 Research background

A mountain area, in *Cihai*, a Chinese Encyclopedia-like Dictionary of Words, is defined as "a landform where the earth's surface stretches above its surrounding areas, presenting a raised topographic feature, while the slopes are rather steep." In the sense of geography, a mountain area refers to a landform with a height more than 500 meters above sea level, and above more than 200 meters above its surrounding areas. However, in the sense of architecture, a mountain is a topographic combination of contour lines with a variety of elevations at a certain latitude. These two explanations form different features of a mountain range and space.

Residences, generally speaking, refer to houses especially designed for people to dwell in. Since ancient times, people have been seeking shelter, which can provide for them a comfortable space and an atmosphere for privacy, which can protect them from foreign invasion. After thousands of years of evolution, residences, which have been following this traditional concept, have become a type of architecture in the sense of architecture in contemporary living environment, an indispensable product of building in contemporary society.

When the words of a mountainous area and residences are put together, they will become a new word, which has its own independent system, and exists in every corner of the world, used by people in every country or region. The construction of residential buildings in a mountain area must to meet the corresponding local conditions, ecology, environment, and engineering.

1.1.1 The present situation of China’s mountainous residences

In the vast territory of China, the proportion of mountains and flat lands is 2:1. In other words, the amount of land in the mountainous areas is roughly twice the amount of land in flat lands. Generally speaking, people often desire to live on flat lands, build houses and create cities there, because in the plain area, it is easier to build up the city running from west to the east, which is more convenient for people to establish communications and contact between each other. Therefore, the urban development and economic development in the plain area are attached more importance to by people, and the first and the second tier cities are often concentrated in the plain areas. We can often see that, in the first-tier big cities, such as Beijing, and Shanghai, row upon row of tall buildings are built everywhere. The transportation is convenient, and people's life index is on the rise. In contrast, the development of the mountainous area is not that optimistic. Because of its spatial structure, land forms and other factors, a mountainous area has been faced with a huge pressure and perplexity for such issues as urban construction and economic development. Because of its economic backwardness and change of people’s concepts, the mountain areas are often the footholds of the rural areas. Although the central government has started the urban and rural integration, with such measures as rural development driven by prosperity in cities, the economic construction of the mountainous areas cannot hope to keep up with the pace of urban construction in the plain region within a short period because of China’s national conditions like the huge population base, and the imbalance of the

proportion of population. In addition, for a long time, people have known little about construction in the mountain areas, and this situation has resulted in improper development, unsustainable logging, and reckless construction, which disrupts the ecological balance of the mountain areas. So, currently, China's mountainous residential building, as the primary and effective form of the mountainous buildings, is still faced with challenges as to such issues as how to make effective plans for the use of land, and how to develop by taking full advantage of the terrain while protecting the ecological environment at the same time.

1.1.2 The hard nut of residential construction in mountainous areas

According to the terrain area statistics of our country, the proportions of land, hills and mountains are roughly 34%, 20%, and 46% respectively, with the land areas of mountains and hills accounting for 2/3 of the total[1]. From the perspective of the structure of land use, of the mountain areas and hills, 41.62% of the total is grass land, 27.42% forest land and 13.54% arable land[2]. According to the analysis of the state land administration, the arable land for agriculture is 5,1970,000 hectares, accounting for 17.1% of the country's total land area. If this part of arable land is guaranteed, the food industry in our country can basically be guaranteed[3]. However, the "2003 China Land Resources Bulletin" shows that from 1997 to 2004, the total area of cultivated land in China has

[1 --3] Qiu Y.R. Talking about the Development of Mountainous Housing from the Present Situation of Forest Land Resources [J], 2004

decreased from 195,100,000 acres (one acre roughly equaling 666.7 square meters) in 1996 to 185,100,000 mu. Within seven years, the cultivated land area hit a record net decrease of 10,000,000 mu. Although the ecological de-farming policy of returning cultivated land to woodlands and grasslands is the main contributing factor that resulted in the decrease of cultivated land, the proportion of non-agricultural construction accounted for 8% of the arable land reduced, significantly larger than the appropriate proportion of 5%-6%[4].

We often say that the two major issues people care most about in life are food and shelter. So, with the increasingly rapid development of urbanization, we not only need to solve the problem of eating, but the problem of living is also a top priority. The people's growing demand for housing, coupled with the limit of the land area in the plains, has gradually turned to farming areas. The reason behind lies in that the quality and environmental quality of vast agricultural land areas are far superior to those in the mountainous areas, and the construction project is understandably much less difficult. So, the report shows that the main factor of non-agricultural construction of farmland is residential construction. At present, the housing construction and cultivated land protection are both major issues related to the national economy and the people's livelihood, but they also conflict with each other because we need to construct housing on the one hand but we also need to protect arable land on the other. So, how to optimize the development of mountainous residences in the most effective way in the current state of environment, and how to protect our

[4] Li H.M. The Development of Mountainous Residential Construction is the Need for Rational Use of Land Resources [J], 2004

ecological environment while meeting the needs of the people is a very hard nut to crack.

In addition, the development of mountainous residential areas can effectively promote the economic development in rural areas and the sustainable development of the city for a long time. In rural areas, because of its vast mountainous areas and limited plat lands, the construction of the residential buildings cannot be developed orderly in a systematical way, so the living conditions of the people in rural areas cannot be effectively improved, which will contain its economic development eventually. Therefore, the development of mountainous residential buildings is a win-win process: the development of the central government cannot be separated from it, while its own development also needs the central government's push and support.

1.1.3 The sustainable-development-oriented model of mountainous residences

At the 2004 China Mountainous Residential Construction and Development Seminar, Chen Zhouqi, a vice director of the CPPCC National Committee on Population Resources and Environment, pointed out that the mountainous residential construction should be people-centered with the aim to keep man and nature in harmony with each other. He also stressed that mountainous residential construction should focus on the protection of basic farmland to solve the outstanding problem of the contradictions between man and soil to make full use of mountain areas to build towns and cities, saving arable land, and taking the

path of sustainable development.

The sustainable development of mountainous residences will promote the construction of rural economy, while meeting the needs of the people and improving the conditions of the living environment, and rendering residences and residents return to nature at the same time. In view of this, it is advisable to set up sustainable- development-oriented policies, while taking into account ecological restoration and conservation to achieve mountainous residential construction in according to concrete local conditions, which will benefit nature, and society in the final analysis.

1.2 Purpose and significance of the research

1.2.1 Purpose of the research

The purpose of this thesis is to provide a feasible plan for the mountainous residential planning and design in China, starting from how to develop mountainous residences on a large scale, and how to best configure land use, and the conditions and norms of current domestic and international mountainous residences, to come up with a preliminary discussion and summary of the domestic mountainous residential planning and design so as to offer an effective guiding point of view to the mountainous residential planning and design.

1.2.2 Significance of the research

Cities generally take broad plains as the foundation areas to build housing, so we usually study the relationship between housing and people's life from the perspective of cities, while those mountainous residences in the rural areas are often ignored. As a result, the inequality between urban and rural construction as well as the neglect of rural construction has led to the current problem.

This research takes the mountainous residences as the research object, discusses the characteristics of the planning and design of the mountainous residences in the rural areas, explores how the development of mountainous residences on a large scale in foreign countries is achieved, how to set up the public space in the mountainous residences, and how to best configure the paths, the nodes and the accessibility of the mountainous residences with outstanding international examples. Meanwhile, the author also considers the importance and implementation of the road networks, sunshine, disaster prevention and other elements for the residences to demonstrate how to carry on sustainable development to mountainous residences from all aspects in a systematic way.

The author believes that this research is a very important supplement to the research in residential areas, enlightening and significant not only for the existing rural residential planning, but also very helpful to people's concern about the rural development as well as the promotion of the national development strategy.

1.3 Methods of the research

With mountainous residences as the research object, this thesis explores the design of sustainable development in rural areas against the national conditions in contemporary China. The research methods include literature research, data collection, case analyses, research, chart analyses, and design suggestions: literature research mainly inquires about the related research of domestic and international mountainous residences, analyzes and compares its research methods and related theories; data collection mainly searches for related information and data of mountainous residences through the Internet; as for case analyses, the thesis mainly selects some typical mountainous residential designs which are of guiding significance, compares their advantages and disadvantages, and analyzes the performance and the reference significance of the cases in the sustainable development design; as far research is concerned, the thesis discovers the current domestic mountainous residential situation, and analyzes its potential improvement mainly by means of field research; the chart analyses are intended to turn the collected data into charts to sum up and draw the conclusion; the design suggestions, on the basis of the above, aim to put forward the tentative design suggestions to provide the theoretical basis for the sustainable development of the mountainous residential design.

CHAPTER 2 | RELEVANT THEORIES, RESEARCHES AND LITERATURE REVIEW

2.1 Residences in mountain areas

2.1.1 A general situation of development of mountain residences

In the process of the development of human history, people have already developed some attachment to the mountains or hills near them. The essence of mankind lies in survival, while survival implies the need for shelter. As far as in the primitive times, people had already formed some idea for survival in the form of nest residences, cave residences, and residences in the trees in accordance with the terrains in the mountains. With the overall development of productive forces and social cultures, people have gradually formed a residential mode of housing. The so-called residence refers to a shelter used for dwelling and living. Under the conditions of development in this broad environment, mountain residences, and mountain houses have emerged one after the other gradually.

In the early human activities, both the Eastern and the Western culture regarded "nature" as a creation of God. As a result, as to mountains, the product of nature which is understood as the ladder leading to the sky, and gods, people, who also cherish a feeling of awe and longing deep down, choose lofty mountains and steep hills as places to settle down for a living and to worship their Gods or deities. The most typical representative is the palace. Ancient Chinese emperors were willing to build their own palaces at the top of mountains, either by the might of a mountain to demonstrate their rights and dignity to

overwhelm the people; meanwhile, they were close to heaven and show off that they were precisely the incarnation of God or Heaven. It is the same with the West; a case in point is Persepolis Palace, the ancient Persian Empire palace, surrounded by the mountains.

With the development of modern civilization, people's living ideas and conditions have made rapid development. As a country with a vast land of territory and a variety of complex terrains, China, which has significant advantages and strengths in this respect, has been capable of providing the living conditions of mountain environment ever since ancient times.

All clans or ethnic groups began to create various houses of their own, such as cave buildings in the Northwest, the Traditional Folk Houses in Southeast Zhejiang, the colossal Hakkanese Earth Buildings in Fujian, and the Suspended Wooden Buildings in Sichuan. In the long practice of civilization, the relationship between the mountainous houses and the mountain areas demonstrates the characteristics of "following the terrain spontaneously." The layout of the houses of the residents in a group is miraculously combined with the terrain and the stream's texture space, so that the buildings are well integrated into nature, forming a variety of roofs of different heights, rich and beautiful in form, and making up a unique residential culture. In the Western cultural world, the rise of mountainous residences are mainly characterized by independent mountain residential groups, detached or semi-detached houses, forming a group-styled mountain residential model, such as the Los Angeles mountain residences in the United States[5] .

In addition, in modern times, some world-renowned architects also have made some

[5] Lu J.W. & H.S. Wang. Hillside Architecture Design, Beijing: China Architectural Industry, 2000

research on the creation of mountain dwellings. For example, in 1935, Frank Lloyd Wright(1867 –1959), the United States architect, who believed in designing structures that were in harmony with humanity and its environment, designed Fallingwater, a villa known as the greatest modern building in the history of the United States. It has achieved great success not only in the handling of space, the combining the size with the surrounding environment, but also turned a great new chapter for the discussion of the model of a single detached mountain residence.

In his architectural career, Glenn Murcutt(1936-), a British-born Australian native architect, has always been exploring how to design a mountainous house that can have a dialogue with nature in the native mountains and mountain environment of Australia, which not only involves the combination with local environmental characteristics, but also pays more attention to the need for energy-saving low-carbon construction, such as Simpson-Lee House. Respect for native land, and respect for nature are his structure-designing creed.

Japan's famous architect Ando Tadao(1941-) won the Pritzker Architecture Prize with the Rokko Housing One. This work has made some great achievement on the intensification of mountainous houses, and has explored the way in which the houses are arranged at different elevations and the way of entry from different entrances, paving the way for a new model of the condominium.

2.1.2 The current situation of mountain residences' development in China

China is a mountainous country, where there are about 6.6 million KM2 of mountain areas, accounting for about 70% of the total land area, and the residents

dwelling in the mountains account for more than half of the total population. Nearly half of the urban and rural areas are located in the mountain environment system: of the more than 600 cities under construction over 300 are mountain cities; of the more than 2,300 county-level administrative regions more than 1,500 are in mountainous areas; of the more than 19,000 towns, nearly 10,000 are mountain towns. These mountainous cities and towns in the mountain environment system have made remarkable achievements in urban city construction, which are quite obvious to all, though there also exist some unavoidable root causes: the accumulation in quantity is greater than the improvement in quality; many just imitate and copy cities in the Western countries rather than dig, inherit and innovate the native culture of their own region.

As far as the urban and rural construction of the mountainous areas, people often apply the theory of urban and rural construction on the plains to urban and rural construction in the mountain areas, or ignoring the safety, ecology, sustainability, regional cultural characteristics and engineering complexity of the mountain environment, bringing about hidden trouble to the ecology in the cities, and towns in the mountainous areas , or cause a huge waste of economic engineering, and such a phenomenon in today's mountain town development is not uncommon.

In the context of the development of modern mountainous cities and towns, the above-mentioned urbanization, which is a partial and monotonous urban construction, has affected the residential patterns in mountainous cities. Like the high-rise and multi-storey residential areas in the plains, many mountain cities follow the their residential model on the plain as far as the construction of mountain dwellings is concerned, resulting in a large amount of soil erosion and the destruction of the balance of their

ecological environment. Consequently, various natural calamities frequently occur.

However, some historical and cultural mountain village houses built long ago still retain their original style an some low-rise bungalows because they lack transport facilities, and information channels. Besides, the economic development there is backward. Despite the advantage of the layout of the mountain residential construction (as they can exploit the terrain when they have their houses built, you needn't do a lot of digging and filling near the mountain), they don't have a clear, comprehensive, and effective mountain residential planning layout design pattern. What can be found there are features of some random, scattered or gathering village cultures. In addition, they are backward as far as disaster prevention and environmental protection issues are concernd; therefore, there exist lots of hidden dangers.

As far as the current development of China's mountain residences is concerned, either the living conditions or the living standards are ideal. Therefore, it is one of the core issues to increase the quality of mountain life by planning the mountainous houses and settlements according to local conditions so as to conform to the regional characteristics of the mountains and to protect the ecological environment as much as possible.

2.2 Theories about the human settlement environment in mountainous areas

As for the research on "human settlement environment in the mountainous areas", the basis of the theory comes from Wu Liangyong, an academician studying "human settlements science" philosophies. "Human settlements science is a science that focuses on the interrelationships between man and his environment, including human settlements (villages, towns and cities included), emphasizing the study of human settlements as a whole, with the aim to

understand and master the objective laws of the occurrence and development of human settlements, so as to better construct the ideal living environment for mankind."

Mr. Wu Liangyong once pointed out: "As for the accumulated knowledge of systematic research on human settlements and the problems about the development of current human settlements in mountainous areas in our country, there still exist a considerable gap between the academic research of human settlement in mountainous areas and the situation in the reality. Therefore, we should learn from history and get theoretically well prepared to adapt to the needs of the times to create a new mountain living environment construction model on a large scale for the city's organic decentralized form of development to bring new possibilities to prevent valuable mountain resources from being abused and destroyed."[6]

The research team of "Mountain Human Settlements Environmental Science", which was started by Professor Zhao Wannong of Chongqing University, aims to provide an effective way to improve the mountainous human settlements in the vast mountainous areas in the West of our country. "Seven Discussions of Human Settlements in Mountainous Environment", the research achievements of his team, attempts to discuss the seven aspects of mountainous human settlements the features of human settlements in mountain areas, and the construction of relevant theories from seven different angles.[7]

[6] Zhao W.M. Theories of Human Settlements in Mountainous Regions, Beijing: China Architectural Industry, 2015
[7] Zhao W.M. Theories of Human Settlements in Mountainous Regions, Beijing: China Architectural Industry, 2015

2.2.1 Scientific Epistemology

In this theory, the research team points out the scientific limitations of the traditional architectural planning discipline, stating that the issues about human settlements in mountainous areas should be studied in combination with the theoretical knowledge of all the other disciplines. What the environmental science of human settlements in mountainous areas needs to do is to explore the material support elements “mountain”, “water”, “people”, and the “city” itself and the relationships between them. This involves all disciplines such as ecology, nature, humanities, landscape, economy, society, and security. Its core object is “people”, fully expressed the relationship between people and the other elements mentioned above: people create a living environment, whereas a living environment will have an impact on the behavior of the people. Based on the main support discipline and related disciplines, this multi-disciplinary support is the most viable development of human settlements in mountainous areas. The environmental science about human settlements in mountainous areas has established a theoretical knowledge system in co-living culture, mountain watersheds, the balance between urban and rural planning, spatial form, disaster prevention and security, engineering and technical aspects of the establishment of a theoretical system, and as a framework for extension and expansion, constructing the scientific framework of living environment research on mountainous areas. (Illustrated by Picture P43)

2.2.2 on the Culture of Living Together As a Group

Culture is the life of the city (Lewis Mumford, 2009). The research team studies the mountainous culture from the following three aspects: embedded value, spatial structure, protection and inheritance.

1) Embedded value

The rapid development of urbanization brought about the convergence of urban cultures, which in turn leads to the over-exploitation of urban cultural resources, and the traditional discourse of power of regional culture gradually gets lost. In order to sort out and restore the importance of cultural value to the construction of mountainous cities and towns, the research team divides the mountainous culture of living together as a group into four levels through the reconstruction of cultural value system and the use of cultural compatibility as a framework.

Material level of culture - corresponding to the diverse forms of human settlements;

Behavior level of culture - corresponding to people's behavior and their demand for space;

Institutional level of culture - corresponding to the local characteristics of the settlement ideas and urban planning theory;

Spiritual level culture-Corresponding to the aesthetic psychology and orientation demonstrated by living together as a group.

Based on this, the research team uses man as the subject, nature as the object, linking the regional culture to human settlements environment, demonstrating that it is necessary to explore, extract, protect, inherit and promote

the diversity of regional cultures and cultivate the consciousness of a regional culture and systematically construct the cultural value system of living together as a group in mountainous areas: cultural ladder, cultural accumulation, cultural ecology, cultural compatibility, cultural values and cultural time and space in view of the forms and problems of mountainous cultural construction.

2) Spatial structure

Based on the spatial relationship between spatial density and regional cultural structure, the spatial structure in form is divided into three levels, namely, macro-, meso-, and micro-levels, according to the spatial structure of mountain spatial units. What's more, in accordance with the basic spatial organizational relationship, macro- or meso- level can be further divided into five categories[8].

a) space culture axis (crankshaft and straight axis): a number of spatial cultural units to form a certain length of cultural belt, where important cultural units form the major nodes.

b) space culture ring: in a long route in series with a number of wonderful space culture unit to form a specific cultural theme or theme group.

c) dumbbell-type space culture level: two strong cultural units form two levels, so that people are attracted to the composition of the cultural space field, followed by some subsequently created culture units to further strengthen this axis.

d) centralized space culture area: the face or sheet of space culture plate structure.

[8] Zhao W.M. Theories of Human Settlements in Mountainous Regions, Beijing: China Architectural Industry, 2015

e) radiation-type cultural center: the city's strongest space in the cultural unit or plate as the center, with the secondary space culture units around it, resulting in radial contact.

However, the micro-level urban spatial cultural structure refers to a spatial cultural unit within the scope of the cultural elements of space, embedded cultures and form of integration.

The research team study human settlements in mountainous areas from the spatial cultural elements to the space culture unit, and then to the spatial cultural structure of the theory and analysis methods before the forms of the living culture and the relationship between urban forms are combed.

3) Protection and inheritance

The adaptive protection strategy and the spatial culture planning stratification into the existing urban and rural planning system are put forward, from theory and practice to realize the mountainous culture of protection and inheritance.

2.2.3 Watershed ecology

Watershed settlement is the most basic mode of human survival and development, with space, environment, and time as the three dimensions of the impact of the role. In order to solve the extensive use of farming and forestry in the mountainous watershed, the river’s cascade development, industrial and mining construction, urban land expansion and the like, which will do harm to the ecological environment of the whole region, the research team put forward the development of river basin resources, ecological maintenance, and

sustainable development ideas of integrated management.

2.2.4 Overall Urban -Rural Planning Theory

To balance urban and rural development is an important part of our national strategy of building a harmonious and powerful modernized society under the unique time and space background. With the logical starting point of balancing urban- rural development as a new village construction idea, and the development of comprehensive reform of Chongqing city as a typical example in China's mountain areas, the research team, by studying the environment construction of human settlements in urban- rural development planning in mountain areas, reflecting upon the real problems of current mountainous regions, and conducting an in-depth analysis of the construction and the layout of the pattern of the countryside residents' living space model from the rural perspective, has finally proposed the four basic settlement patterns[9]:

1) the town-based community settlement pattern;

2) the industry-based settlement pattern;

3) the infrastructure-based block-shaped or band-shaped settlement pattern;

4) the resources-featured scattered settlement pattern.

2.2.5 Theory for Space Forms

Cities in mountainous areas, constrained by their unique ever-changing space, are characterized by their uniqueness, diversity, multi-dimensions and complexity displayed in their spatial forms, which demonstrate significant differences between cities in mountainous areas and cities on the plains. As a

[9] Zhao W.M. Theories of Human Settlements in Mountainous Regions, Beijing: China Architectural Industry, 2015

result of the rapid urbanization in China, the landscape pattern of a great number of mountain cities has made enormous changes, ignoring the basic law of the choice of construction sites. The mountain city space is becoming a plain, so the characteristics in space are gradually lost. Faced with this phenomenon, the research team explores the development view of the spatial form of the mountain city from the perspective of the form, structure and evolution of the mountain city, discusses the humanistic view of the mountain city space from the public space composition and structural features of the mountain city to establish the basic understanding of its spatial form.

2.2.6 Disaster Prevention and Safety Theory

Geologically speaking, mountain areas are vulnerable to multiple disasters. After a multidimensional analysis of the formation and elements of mountain disasters, the research team put forward the theory of “induced spatial disasters” to deal with natural disasters. The theory model is as follows:

Disaster avoidance—disaster reduction—disaster prevention—disaster relief—post-disaster reconstruction—Disaster avoidance (circulation of the above-mentioned patterns)

In addition, the research team, based on the theory, puts forward the evaluation model of disaster prevention and control of the mountain city design, establishes the evaluation principles and standards, and proposes the efficiency evaluation of disaster prevention of the mountainous living environment.

2.2.7 Engineering Technology

The construction technology of human settlements in mountainous areas is a

scientific and technological system aimed at establishing a safe and economical mountainous living environment in a complex terrain environment and a sensitive ecological environment, and fundamentally changing the phenomenon of "travel basically relying on human feet, communication mainly relying on shouting aloud" in the less developed mountainous areas. Mainly from the adapting human settlements to the mountainous areas to meet the transport conditions and municipal drainage construction project, the research team discusses multidimensional control of the human settlements' environment in mountainous areas. As for transport road arrangement, the three traffic-flow re-organization technology has been put forward to achieve the cubic easy-to-pass-through transport strategy in mountainous areas[10]:

1. One-way traffic reorganization of the streamline;

2. The central city center, sub-central city air walk corridor streamline;

3. The walk streamline in mountain cities.

As for the construction of the municipal drainage project, the team has proposed the adaptive construction:

1. When constructing the drainage system, the team proposes that we should take the changes of the mountain terrains into account and build the system in accordance with concrete conditions;

2. The layout of the drainage system should be considered as a whole;

3. The layout of drainage pipes should be arranged in a scientific way;

4. Rain prevention and flood prevention should be taken into consideration.

[10] Zhao W.M. Theories of Human Settlements in Mountainous Regions, Beijing: China Architectural Industry, 2015

2.3 Theoretical Research on Foreign Human Settlements in Mountainous Areas

Garden City Theory

The Garden City, also known as the idyllic city, was a city planning concept put forward by Ebenezer Howard(1850- 1928), England, in 1898, in his book *To-Morrow: A Peaceful Path to Real Reform* (1898), in which he describes a utopian city in which people live harmoniously together with nature, enabling people to live within a city like a garden, balancing residential, industrial and agricultural areas. He stressed that the future of the city needs to be an effective combination of urban and rural areas, forming a mutual penetration of regional integrated management thinking. It has both favorable conditions of urban and rural areas, abandoning the unfavorable conditions of both, and forming a city structure centered around the six monomers. Now, the theory has gradually developed to emphasize the scale of the spaciousness, the combination of architecture and the environment as well as the emphasis on the concept of landscape planning.

Organic Architecture

Organic Architecture originated from modern architecture theory and creative ideas in the United States in the 1920s. In 1900, American architect Louis Henry Sullivan clearly put forward the view of organic architecture, emphasizing the organic combination between the form and functions, as well as the whole and the details. Subsequently, the famous American architect Wright carried it further forward, and promoted it as a creative trend for modern architecture. Its main ideological characteristics can be summarized into the four

following aspects:

1. the integrity and unity of an architecture, specially highlighting the unity between vision and art, often with the sketch of the motif from the beginning to the end;

2. freedom, coherence and integration in space, advocating “open planning”;

3. the visual characteristics of the material and the form of beauty;

4. the unity between the form and functions, advocating starting from the nature of things and designing from inside out.

Counter Urbanization Theory

Counter-urbanization refers to the phenomenon of urban population returning to suburban areas, rural areas and small towns. It is actually a form of architectural organic theory. Counter urbanization is the new trend when urbanization development has developed to a certain stage. The higher the level of urbanization, the stronger the trend of counter-urbanization. To urbanization, counter-urbanization is a way to “get rid of the stale and take in the fresh”; meanwhile, it is an enormous amount of energy for the development of towns and villages. Its main positive influences lie in the reduction of suburban differences, the shrinking size of the city, and the rapid development of rural areas.

Genius Loci

Norway’ famous urban scientist Christian Norberg-Schulzput forward the concept of Genius Loci in 1979, pointing out that in a sense, a person gets an identity and have a sense of belonging for a certain place, and that is the

embodiment of materialization and spatialisation of a person's memory. When we talk about structure, we should start from "Loci" , and discuss how to reward our environment to obtain its most fundamental significance and value.

TOD and TND theory

The designing model of TND (Traditional Neighborhood Development), namely the traditional neighborhood development model, proposed by Andrés Duany and E. Plater-Zyberk, gives priority to the structures of public spaces and public buildings, and treat the public space, green fields, squares as the neighborhood's center, through a modest increase in building floor area to reduce development costs. TOD (Transit-Oriented-Development) is a bus-oriented development model, proposed by the new urbanism representative P. Calthorpe; it focuses more on the entire metropolitan city region, with public transport as the hub, comprehensively developing the pedestrians' community; the two have formed various small groups of coordinated organic development model. The thing the two share is that they both reflect the most basic characteristics of New Urbanism: the compactness of the community, the creation of walkable neighborhoods,, the efficiency of land and infrastructure, and valuing the environment.

Sustainable development theory

Sustainable development refers to the phenomenon that it not only meets the needs of contemporary people, but also does no harm to the needs of the future generations to develop their environment. In other words, it refers to the coordinated development of economy, society, resources and environmental

protection. They are an inseparable system for the purpose of economic development and the protection of the atmosphere, fresh water, sea, land and forests and other natural resources as well as the environment as a whole, so that the future generations' life , and work will not be affected. Instead, they will develop their society in a positive way and live a contented life.

The sustainable man-land system theory aims to explore the view that the socio-economic development can not surpass the capacity our resources and environment can bear. Sustainable development is based on natural resources in harmony with our ecological environment. It requires economic construction under the protection of the environment and the sustainable use of resources to ensure the sustainable use of natural resources and environmental costs, so that human development within the Earth's bearing capacity. To achieve sustainable development, the rate of consumption of renewable resources must be lower than the rate of renewable resources, so that the use of non-renewable resources can be supplemented by alternative resources.

CHAPTER 3 | THE HISTORICAL DEVELO P-MENT OF THE MOUNTAINOUS RESID ENC-ES IN HAWAII AND MAINLAND CH INA

3.1 The historical progress of the development of mountainous residences and the utilization of mountain areas in Hawaii (from the period of primitive tribes to the time before the power vehicle came into being)

3.1.1 The origin of the mountain residences in Hawaii (before 1778)

Hawaii's native inhabitants were Polynesians coming across the Pacific from afar in prehistoric times. As the earliest archipelago natives in primitive tribes, they lived a traditional life on the island, and established their own tribal territories and living houses. Due to the backwardness of prehistoric construction technology, the natives' houses were mainly in the form of Grass-thatched Houses built with thatched roofs and wooden structures. As the natural conditions in Hawaii are mountainous, the steep and dangerous mountains pose a great challenge to their life, not only because of the toughness of their exploitation, but the characteristic of their roughness, bursting the visionary bubble of the local people living on mountains. Therefore, nearly all of them lived on the flat areas at the foot of the mountain along the coast, and occasionally some of them lived in a relatively gentle valley. Its living mode was basically in

the form of Grass-thatched Houses where the tribes lived together. Those grass-thatched houses were settled in the way of units, and each grass-thatched house represented one family of the ethnic groups. There was no particular order in arrangement among houses and the concept of the road had not yet formed. It was basically a living environment and conditions of a primitive and ecological archipelago tribes. In addition, early natives took farming as their basic source of living and their farming fields were also attached to the plain areas at the foot of the mountain and some gentle valleys. (Fig. 3.1)

Fig. 3.1 The origin of the mountain residences in Hawaii
Source: <*Hawaii Looking Back*>

3.1.2 Development of residences on mountain slopes and the use of mountain areas in Hawaii in the nineteenth Century (1778-1900)

The nineteenth century was a very important period for the development of cities in Hawaii. Urban elements were gradually formed in the tide of modern

times, and their corresponding living conditions and environment had changed with the changes of social system. Dwellers gradually expanded their coastal living areas, and started to develop and use the mountains as a common place of residence. By the end of nineteenth century, there was a gradual tendency for mountainous residences.

At the end of eighteenth century, with the influx of European white people and a large number of prefabricated western-style houses they built, the residential pattern changed greatly in Hawaii. Due to the unique geographical advantages of the coastal plain, the valley with natural streams (e.g. Nuuanu Stream) and plentiful foods, the Honolulu area along the coast was regarded as an ideal anchorage for the Western ships and a suitable place for European to stay and build houses. In the vicinity of this region many mixed villages and towns had developed rapidly, presenting a scene of the coexistence of local aboriginal cottages and Western prefabricated houses. In 1795, in order to develop agriculture and animal husbandry, Westerners introduced cows into Hawaii, which brought some trouble to the local natives. Free ranging cows often could not help but to eat the grass covering the aboriginal houses, which greatly affected the life of the native people. In order to solve this problem, natives built up a wall with stones as a fence to prevent the cows from damaging their houses, and this method initially formed the concept of roads created in the form of a zone. During this phase, most of the houses and villages dwelled near the coastal areas of Honolulu. At the same time, the terraces used for the

production of taros were also distributed in this region. As the foundation of life, the villages and towns were located in the plain areas. At the foot of the mountain valley area, the living model was not colorful because it was far from the port. On the contrary, many farmlands were on the gentle slope areas of the valley to develop agricultural industry. (Fig. 3.2)

Fig. 3.2 The end of Eighteenth Century
Source: <*Hawaii Looking Back*>

In the early nineteenth century, with the influx of Western merchants and missionaries, a large amount of material resources were brought in as they started trade colonization, forcing Hawaii to urbanize, and one of the major initiatives was to expand trade and commodity colonization areas. The colonial land scope of original coastal areas obviously could not meet the needs of more and more Westerners as they arrived. Therefore, the original agricultural terraces besides the villages where produce taros were gradually replaced by the newly-built residential community. At the foot of the mountain, a large number of residential communities were established in the plain areas near the coastal port. These residential communities were built for Westerners to live, the construction materials of which were made from coral grass, wood and bricks. The residential

area was gradually extended to the farmland, intersecting with the farmland, for there was no new road system. Therefore, the residential communities took low stone walls as their boundaries, so as not to get involved in the agricultural region. At that time, the transports could only rely on donkeys and mules, and the traffic was extremely inconvenient, so in the mountain system whose valleys and slopes were relatively distant from the coast, the utilization of mountains was rather rare, and there were very few residential houses. (Fig.3.3)

Fig. 3.3 Starting of Nineteenth Century Source: <Hawaii Looking Back>

By the mid-19th century, more and more new communities had occupied the port of Honolulu. Only a very small part of the indigenous people still retained their thatched houses. The development of goods and trade led to the construction of the whole city of Hawaii. Urban roads and streets formed in the even areas. The city gradually began to extend to the valley slope area. In this stage, some rich Westerners preferred to live in a valley where the natural

environment was better, such as Nuuanu Valley. These areas were vast in land area and were relatively even, and full of rich land resources. Also this region had a relatively cool temperature and humidity because of the trade winds' and the mountain winds' streaming and the rich rain. A large number of communities were separated by fences, and the roads were clearly visible, but still paved with soil. In developing communities, houses were mainly in the form of independent villas. Each house occupied a piece of land and had a small courtyard space. From this chart, we can see that in this period, Hawaii's residential community construction had already developed its initial formation on the even slopes of the valley led by the rich people from the West. In other plain areas, clear dividing roads occurred. However, due to the pursuit of rapid development of goods, juxtaposition of residential communities and industrial factories, its development was not ideal: the muddy roads, grass-thatched houses, houses, and untreated courtyards, were ubiquitous. (Fig. 3.4)

Fig. 3.4 Mid of Nineteenth Century
Source: <Hawaii Looking Back>

By the end of the 19th century, the use of the mountain and the development of the mountainous residences gradually emerged as a result of the reformation of transportation in the city. Before this phase, most of the people living in Honolulu took walking and riding horses as their means of transportation. By the end of the nineteenth century, carriages emerged, which signified as the earliest bus, whose moving form is to use the horse or mule as the traction vector and bind the rope to the four-wheel box car for dragging forward. This kind of transportation aroused a widespread concern in the city center of Honolulu. In 1888, the first carriage track was built and put into use in the city streets. After a few years, the carriage track and its operation developed in a more mature way, which led a substantial expansion of the city streets and molded a grading system for human vehicle shunting roads of the sidewalk and the carriage trail. The valley used to a rural area because of its distant position from the port, and it was quite inconvenient for people to move from the valley to the port before the appearance of the carriage. Thus, the emergence of carriages not only promoted the development of Hawaii's urban road system, but also provided the possibility for people to live in the mountain areas. From the development plan of Honolulu in 1902(Fig. 3.5), we can see that in the late 19th century and early 20th century, the Honolulu region had a well- shaped urban road system, and some of them extended to the valley areas of Nuuanu Valley. Most of the residences were located in the urban area; but a number of dwellings began to make their appearances on the gentle slopes of the valley, although the road networks

connected with the city were quite few because there was only one or two major climbing roads. However, to a certain extent, it had laid a solid foundation for the extension of the residential living space. In this period, however, most of the other parts still retained the agricultural industry, and there was very little living space.

Fig. 3.5 The End of Nineteenth Century

Source: Author editing from *Hawaii Territory Survey Map 1902*

3.2 The relationship between the characteristics of the historical development of the mountainous residences and the road traffic in Hawaii (before the existence of power vehicles)

Throughout the historical stage of the development of hillside residences in Hawaii, its main development features are as follows: the initial stage of the development of road transportation and the changes in the distribution of hillside residential areas, which interact very closely with each other, and have become the main historical development characteristics of hillside residences in Hawaii.

The historical development of the mountainous residences in Hawaii region has a very close connection with road traffic. In the early times of Hawaii, due to the lack of transportation technology, and because of the twists and turns, ups and downs of the mountains, few people chose to live in a part of the mountain system (such as mountain valleys, and mountain slopes), because it was far away from the coastlines. Most people dwelled in even coastal areas, because the terrain was relatively suitable for living in this area, and they could carry on daily life on the coast. Therefore, in the early development of Hawaii housing, urban residential areas were often distributed in the Honolulu port region.

With the development and expansion of urban areas, the existence of horses, donkeys and mules as the primary means of transportation gradually formed a preliminary road system in the city areas. Due to the expansion of the Hawaii resident population, people started to think about how to increase and expand their living space while satisfying their life needs. Thus, Hawaii residents

began to exploit the mountain areas as a new living environment and mode. The primary vehicle also carried the remote task of the connections between coastal urban areas and mountainous areas. Sporadic residential houses were emerging in the valley, but the mountain road in the real sense had not yet been come into being.

By the end of nineteenth century, the emergence of the carriage had made a new breakthrough to the development of urban planning of Hawaii. The arrival of the carriage brought the Oahu region traffic tracks, expanding the city's road system, and further enhanced the accessibility of urban traffic. In addition, it also provided the necessary feasibility of living in mountainous space for urban residents. In this stage, the urban area roads gradually became clear, and some residents began to move towards the areas of Nuuanu Valley. In the areas of Nuuanu Valley, there were two main traffic corridors connecting urban areas with the mountainous terrain, and the residential communities were distributed near the main road. Besides, in this mountain area, the construction of a straight highway named Pali Highway that connected the windward with the leeward of the even areas of the mountains; the city’s construction, therefore, took a new step in expansion. In all, before the advent of power vehicles, the development of the mountainous residences in Oahu District of Hawaii experienced an inevitable stage from scratch. With the emergence and completion of the primary vehicle as well as the corresponding urban road system, the urban area gradually formed a trend towards the expansion to the mountainous areas. Although most of the areas were still the fields for

agriculture in the late nineteenth century, but the expanding phenomenon of the small part of living space and urban space to the valley area also laid a foundation for the planning and development of the mountainous areas in Oahu District, Hawaii. (Fig. 3.6)

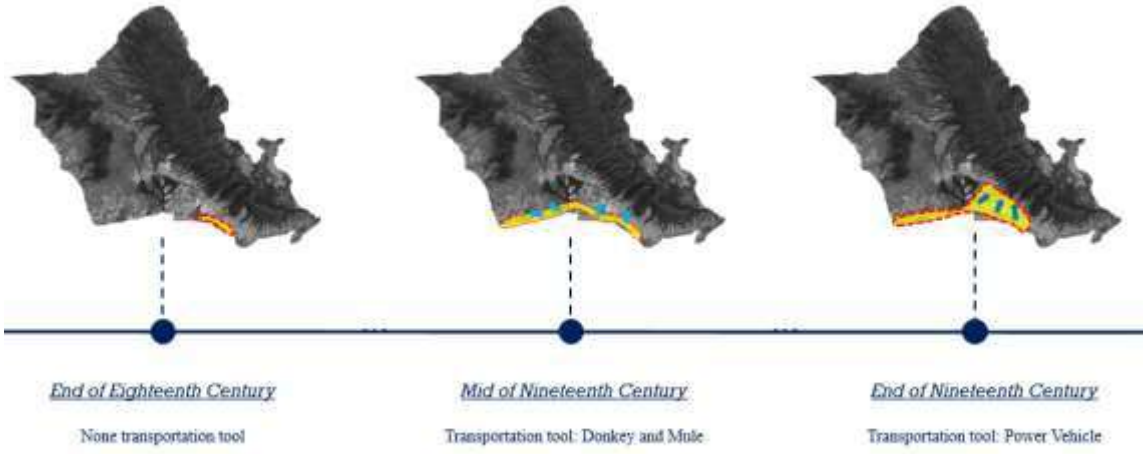

Fig. 3.6 The development of Oahu's mountain residences
Source: Author

3.3 The Characteristics of the Historical Development of Hillside Residential Development and Mountain Utilization in China

China boasts of a long history with a vast territory, and her natural geographical environments are not always the same. In its long historical development, different forms of residential buildings have gradually come into existence all over the country. This kind of traditional regional architecture is greatly influenced by its corresponding local geographical environment, which vividly represents the close relationship between man and nature.

The residential quarters in mountainous areas in our country can be traced

back to folk houses in the mountains. As for the historical development of houses on the slopes of mountains and hills as well as the historical process of the use of them in our country, the traditional mountainous folk dwellings and settlements in our country can be said to have played a relatively important role in the development of the residential quarters in mountainous areas. In the practice of long historical development, the relationship between mountains (hills included) and residential dwellings can be described as “people normally have their residences built according to their respective terrains.” To study the historical development of the residential quarters in mountainous areas and the use of these areas, the study of the relevant residential quarters is indispensable. In the distribution of various types of traditional mountainous houses and settlements, the development of the residential areas in the Southwest is undoubtedly of great significance for the study of the development of the residences on the hillsides or the slopes of the mountains.

Fig. 3.7 The Southwestern mountain area in China
Source: Author

3.3.1 The Development of Traditional Residences on the Hillsides or the Slopes of the Mountains in Southwest China

The southwestern region, which is mainly made up of Yunnan, Guizhou, Sichuan, Chongqing, and Tibet in Southwest China, is primarily occupied by such minor ethnic groups as the Miao Ethnic Group, the Buyi Ethnic Group, the Dong Ethnic Group, the Bai Ethnic Group, the Gelao Ethnic Group, and the Zang Ethnic Group (the Tibetans). As a result of the rugged geographical characteristics in the southwestern region, the different ethnic groups are independent of each other, and the residential cultures and strongholds are separated from each other, and the buildings different groups live in are not always the same. For example: Tibetans' Fort Houses are a typical form of habitation on the Qinghai-Tibet Plateau in Southwest China and parts of Inner

Mongolia in North China; the Ganlan-style Bamboo Houses in Yunnan are the main form of residences of such ethnic groups as the Wa Ethnic Group, the Dai Ethnic Group, the Miao Ethnic Group, the Jingbo Ethnic Group, the Hani Ethnic Group and the Blang Ethnic Group; while the Suspended (Wooden) Buildings and stone houses are typical residences for the native people in Chongqing and Guizhou.(Fig. 3.8)

Fig. 3.8 Traditional hillside residences in Southwestern China
Source: Author

As a result of different forms in different subcultures, the traditional residential quarters in mountainous areas in the Southwest Region have evolved a distinctive form of habitation characterized by “Da Za Ju, Xiao Ju Ju”.

“Da Za Ju” refers to the integration of different ethnic groups in the Southwestern Region, or different ethnic groups mix with each other. Its multicultural and ideological combination has formed the residential feature of Za

Ju (mixture) in a broad sense in Guizhou's folk houses; while Xiao Ju Ju refers to the fact that different villages or hamlets (usually a small group of people from a particular ethnic group) indifferent mountainous areas have developed their unique dwelling forms of living together and even unique ideologies. For example, the Miao Ethnic Group mainly dwell together in Guizhou province. However, as small groups often live independent of each other and fairly far away from each other blocked by topographic barriers, there are significant differences between the styles of their folk houses and villages. Therefore, small groups of people with blood as the links of their different clans tend to dwell together and this is the chief form of traditional settlement that has been existing in the Southwest for thousands of years in the past. This residential form of settlement in the Southwest has developed a Shangri-la life where people live together in isolation with the outside world but remain contented with their self-sufficient economy.

3.3.2 The Developmental Characteristics of Traditional Mountainous Dwellings in Southwest China

Although the ways of habitation of each ethnic group in the Southwestern region are independent of each other due to the limitation of geographical conditions, there is some similarity in their utilization of the lands in the mountain areas

1)***Boundary and centrality***

As the traditional mountainous houses in the Southwest Region are

mainly dominated by the natural villages of different ethnic groups, these ethnic groups tend to have their activities in groups as a rule ever since ancient times. They usually choose a suitable hillside area or mountain slope suitable for residential construction, where they can easily access favorable natural environments such as a farmland water system, to form a self-sufficient living area. The area they have settled down is naturally demarcated from the outside world, so we can often find such a living pattern of a group of people who choose to live in mountainous houses in an areas surrounded by mountains, which serve as the boundaries of their settlement. And within the ethnic groups, they usually have developed a living pattern of "huddling together for warmth", forming the distributive expansion from the center to the boundaries, as well as the inward centrality. (Fig. 3.9/3.10)

Fig. 3.9 Boundary; **Fig. 3.10** Centrality
Source: Author edit

2)***The layout of facing the water with the mountains behind***

The traditional residences in Southwest China are usually located in the sites which face the water in front with the mountains behind. As the land transport in ancient times was underdeveloped, and the mountain areas are relatively

backward and isolated, the residents there mainly rely on water as an important means of transport and most villages are built by the river. Also, because the Southwest mountain region is vast, and the terrain are rather ups here and downs there, it usually has formed the way of habitation with three sides surrounded by the mountains and one side facing the water. (Fig. 3.11/3.12)

Fig. 3.11 Boundary; **Fig. 3.12** Centrality
Source: Author **e**dit

3)***The residential layout of "Chong Wu Lei Ju"***

According to "Huayang Guozhi(Records of Huayang State)" by Chang Qu in the Eastern Jin Dynasty(317－420), all over the mountain city of Yu Zhou in the Han Dynasty(202B.C.—220) were "Chong Wu Lei Ju" or "Closely Built Two- storey Houses." From this, we know that the natives in the mountain areas in Chongqing City, Guizhou Province and some other Southwestern regions started to have their houses built closely with the mountains behind and the river in front of them as early as 2,000 years ago. This intensive residential layout, on the one hand, is due to the fact that in the early historical period, people were still not good at the exploitation of land, which leads to the closely built form of two-storey

houses as a result of the limited land for buildings; on the other hand, it is also well adapted to the climatic conditions to create an effective space for residents to beat the heat in hot summer. Besides, it is also consistent with the previously mentioned characteristics of the boundaries that the gap between houses is quite small and the overall density is high, which forms a sharp contrast with the outside world (Fig. 3.13/3.14).

Fig. 3.13 Boundary; **Fig. 3.14** Centrality
Source: Author download from Internet

Take the Upper Langde Village (a Miao Ethnic Group village in Guizhou Province) for example (Illustrated by a picture). Because of the uneven terrains, the village is in the form of a group of closely built enclosed courtyard-style houses in that the paths and steep slopes naturally separate households' living spaces from one another. The households are often closely built and the distance between two households is usually very narrow, with only a 1.5-meter stone path between. The village roads are narrow and bumpy, and such a practice also allows the number of households in the settlement in the available mountain and hilly terrain space to get the greatest degree of development, forming close layers of houses expanding outwards in accordance with the conditions of the mountains.

3.4 A Comparison of the Historical Development between Mountain or Hillside Residences in Hawaii, USA and Those in China

In the historical development of the hillside residences, the mountain or hillside residences in Hawaii and China developed in different ways as public transport means hadn't come into being. The major differences are manifested in the pattern of the residential layout, the treatment of courtyards and public space, and the development of the road, while their similarity lies in the fact that it is difficult to access or contact these mountain or hillside residences.

Differences:

Residential layouts:

In the historical development of mountain or hillside residences in Hawaii, the United States, the residential layout patterns are rather random and free, and most of the patterns are scattered, so there have been no fixed integrative rules from prehistoric times when they were widely distributed on the coastal plains at the foot of a mountain. Later on, to further expand their living space, they began to exploit valleys and gentle hillsides or mountain slopes as their development destinations. Independent residences normally have a large private space and land space.

However, the development of our country's hillside residential houses is quite another story. In the residential areas of the Southwest, for example, people often adopted the layout of "Closely Built Two-storey Houses" with small intervals between different households. With the contour lines closely spaced and overlapping each other, individual houses will occupy limited private spaces. Moreover, in the course of historical development, people from the same

ethnic group have often come to live together, forming boundaries and exclusivity.

Courtyards and public space

Although there is no specific pattern of hillside residential layout in Hawaii, the United States, each household has its own courtyard space, separating itself from the outside world while its public space is the space between neighboring households, mostly road space for pedestrians, which is relatively spacious and accessible.

However, as the layout of the "Chong Wu Lei Ju" emphasize the high density and uniformity within the same ethnic group, the hillside houses in our country normally do not have their own courtyard spaces (their farmlands excluded); as for the road public space connected with different heights of houses, its space is very narrow to meet the need of the density of houses.

Road Development

With the emergence of horses and mules, the development of the roads on the mountain slopes in Hawaii gradually developed from the dirt road as its original form to the asphalt road; and as the number of hillside houses has gradually increased, people there have also begun to develop the hillside or mountain slopes as a means to expand their living space.

However, as a result of the general background of our national culture, the layout of the mountain roads in our country has not yet made any ground-breaking progress in the hillside residential history. Instead, it has still retained its original pattern, that is, the relationship between the original road mode and the

residential layout.

Similarities:

Both patterns have difficulty in contacting or accessing the households on the hillside houses or houses on the mountain slopes. In the Hawaii mountain system, more people prefer to live in the coastal port areas or on the gentle slope at the foot of the mountain for the sake of convenience in transport. The difficulty in approaching those living on the mountain slopes has become the main bottleneck in the history of residential development in Hawaii.

In the mountains of Southwest China, ethnic groups live in a region in the form of taking root there, forming a self-sufficient living situation, which is isolated from the outside world as a result of the wide range of mountain terrains. The difficulty in approaching those households living on the slopes has also compelled the hillside residences in our country, to some extent, to maintain the state of isolation and therefore assume different styles in their historical development. (Fig. 3.15)

	Residential layouts	Courtyards and public space	Road Development
Hawaii	Rather random and free; Scattered; No fixed integrative rules;	Independent residences normally have a large private space and land space; Relatively spacious and accessible;	Developed from the dirt road as its original form to the asphalt road;
China	"Closely Built Two-storey Houses" with small intervals between different households; With the contour lines closely spaced and overlapping each other;	Emphasize the high density and uniformity; No courtyard space; Road public space is very narrow;	Retained its original pattern; Not make any ground-breaking progress in the hillside residential history;

Fig. 3.15 Differences between Hawaii and China
Source: Author

3.5 Summary

This chapter mainly studies and compares the historical development of hillside residences and the historical process of the land use between Hawaii and China. The main feature of this characteristic is that there is no public power vehicle, that is, there is no large number of road planning so far. This chapter describes that at this stage, there are different development characteristics and similarities between them as well.

In the historical development of hillside residences and the historical process of land use in Hawaii, this chapter mainly explains the development experience of the hillside residences in Hawaii from scratch through the study of the origin of the hillsides before 1778, and the relationship between the process of mountain exploitation and the emergence of the road in the 19th century. With the emergence and completion of primary transportation and the corresponding urban road system, the urban region has gradually developed the tendency of extending to the mountains. And the study of the characteristics of the relationship between land development and the road shows that there is a phenomenon that the living space in Hawaii has been extending from urban areas to the mountain areas. The concrete way is also being studied.

In the historical development of hillside residences and the historical process of land use in our country, this chapter mainly expounds the basic characteristics of mountain houses originated from mountain dwellings through the study of the historical development of mountainous residential areas in Southwest China. It has also come up with three common points of the

Southwestern mountain dwellings: boundary and centrality, water-in-front-and-mountain-behind location, as well as the layout characteristics of "Da Za Ju, Xiao Ju Ju", which emphasizes the concept of "different ethnic groups mixed with each other whereas people from the same ethnic tend to dwell together in concrete areas" in the history of mountain residents in our country.

Finally, the fundamental similarity has been put forward that it is no easy thing to approach those households living on the mountain slopes in Hawaii and China before powered transport was invented through the three characteristics of residential layout pattern, courtyards and public space, as well as the road development, and by comparing the differences between the two.

CHAPTER 4 | THE MODERN PLANNING DEVELOPMENT OF THE MOUNTAINOUS RESIDENCES IN HAWAII AND THE DEVELOPMENT OF DOMESTIC MODERN MOUNTAINOUS RESIDENCES

4.1 The development process of the mountainous residential planning in Hawaii (From the emergence of power vehicles to the current stage)

After the initial period of Hawaii mountainous residential development and the use of the mountain in the nineteenth century, the twentieth century witnessed the rapid growth of Hawaii mountainous residential development and the use of the mountain. Five major residential housing groups in the valley have emerged, namely Kalihi Valley, Nuuanu Valley, Makiki Valley, Manoa Valley, and Palalo Valley. Five major residential housing groups in mountainous areas have also come into existence, which are Alewa Heights, Pacific Heights, Makiki Heights, Saint Louis Heights, and Maunalani Heights, which presented a different development status in the development of different stages of the whole twentieth century, and their significant changes reflected the modern planning development of the Hawaii mountainous residences on the whole. (Fig. 4.1/4.2)

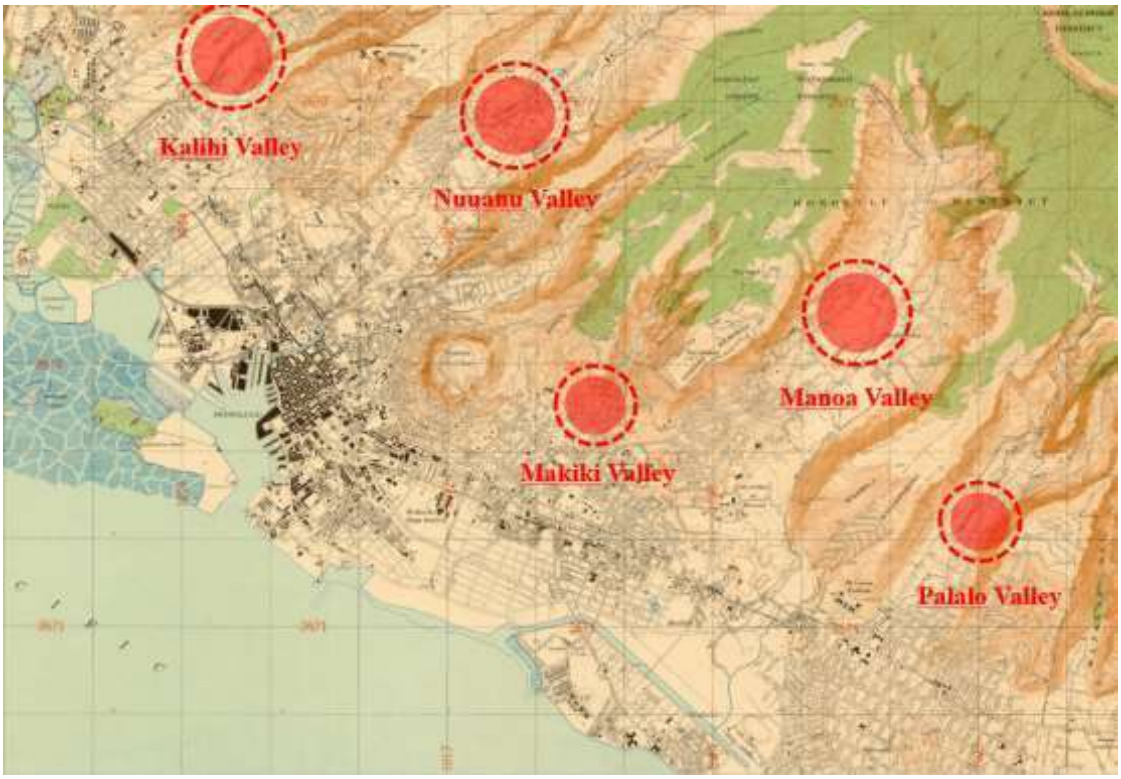

Fig. 4.1 Five major residential housing groups in the valley
Source: Author

Fig. 4.2 Five major residential housing groups in mountainous areas
Source: Author

We have mentioned in the previous chapter that at the end of nineteenth century, due to the prevalence of the carriage, the road planning of Honolulu city of Oahu District, Hawaii had a new breakthrough, for people began to notice the favorable conditions and feasibility of taking the development and utilization of the mountain as a new living space. So, at the turn of the century, a small part of the residential groups began to build residences in the valley areas of Nuuanu Valley, and two main roads were built up to connect the valley and the urban areas. However, in other parts of the mountain, there were still very few living groups, as the state of large original agricultural areas was still maintained.

Beginning in the 20th century, the emergence of steam power trains and the first batch of motor vehicles provided a timely opportunity for the sustainable development of Hawaii City and its residences. The arrival of motorized vehicles forced the Hawaii urban areas, which used the carriage as the main means of transport in the past, to reconsider the new urban transportation mode and the reform of urban roads. City roads changed into paved roadways, and in order to meet the smooth passage of traffic, roads were gradually widened or broadened and the road networks became more abundant. The formal appearance of the tram changed the transport operation mode of the end of last century, for you would have spent more money and longer time for the same long distance in a carriage. By comparison, the tram was light and fast, and with larger capacity and higher efficiency, bringing great convenience to the residents and tourists. Under the conditions of this great environmental advantage, the development of

the city began to extend to the mountains gradually, people living in the mountain areas no longer had to worry about the problem of the inconvenience of the greater distance with the city, and residential groups gradually began to emerge in a number of valleys and mountain slopes

A comparison between the 1912 urban plan and the 1933 urban plan (See Appendix.) in Honolulu city (see Appendix I), Hawaii shows that the road network density and the group that settled in mountain areas of the city and the residential groups of Honolulu region of 1933 had improved significantly. In 1912, the power locomotive was just introduced and was not widely available, although urban and residential planning was still quite fragmented, and there were just a few residential group plans only in the two valley areas of Nuuanu Valley and Makiki Valley. There were relatively sparse road networks, but the Hawaii mountain residential planning in the premise of feasible traffic conditions had first appeared. After 20 years of development, in 1933, the urban areas had been significantly expanded, and the development of mountain areas entered into an unprecedented stable development. Compared with the development of the residential plan in mountain areas in 1912, the mountain residential groups of 1933 had developed from the original two valleys (Nuuanu Valley, and Makiki Valley) to a group of five valley living groups(Kalihi Valley, Nuuanu Valley, Makiki Valley, Manoa Valley, and Palalo Valley) and five mountainous living groups(Alewa Heights, Pacific Heights, Makiki Heights, Saint Louis Heights, and Maunalani Heights). Among them, the valley living groups of Nuuanu Valley and Manoa Valley and the mountainous living groups of Alewa

Heights and Maunalani Heights developed relatively comprehensively, for their residential road networks were more intensive, the resident populations were larger and there was relatively a greater number of residential households. Nuuanu Valley and Manoa Valley were valley areas surrounded by two mountains, which were far away from each other. They had a wide range of terrains and gentle slopes, so they planned and developed a number of main roads accessible to urban areas, and along the main road were distributed contour roads according to the concrete conditions of the mountain terrains, connecting the various residential areas with each other. From the chart we can clearly see that classified roads connected with each residential area were mostly distributed in parallel to the contour of the mountains, and then the sloping roads which were perpendicular to the contour lines connected with the graded roads; The residential buildings were located in mountainous plots surrounded by graded roads and sloping roads, paving the trend for people to dwell in the valley to dwell in mountain areas and then spread to areas of different heights. Alewa Heights and Maunalani Heights are the steep slopes of the mountain areas, and the planned path consisted of one or several main roads linking the slopes and the foot of the mountain, which connected different residential areas by means of several graded roads. There were quite a number of residential units and the main sloping road met the standards of the planning in the way of vertical to mountain contour. Graded roads seemed a little random for connecting the residences of different heights, so the arrangement of residential units were relatively irregular. And the rest living groups formed

in the mountain areas and valley areas had not been fully developed in this stage, as their mountainous roads were relatively sparse, with only one to two climbing trunk road connected. Classifications of the roads were not yet planned, and most of the residences scattered here and there irregularly.

After the Second World War, the development of the mountainous residential areas in Hawaii reached a new height. From the picture of urban plan development in 1953 (See Appendix), we can see that the road network of city and residential area roads was much better than that of 1933, and the roads, which began to graded, were divided into three types, heavy duty, medium duty and light duty. The heavy duty roads run through the whole city region, with urban expressways as their major ones; The medium duty roads, which usually connect each district of the city, include residential areas of mountainous terrains and urban areas; the light duty roads, which are usually referred to as secondary roads, are a medium to connect various destinations with medium duty roads. With the road network getting increasingly clearer and the clear division of road grades, the use and development of the mountain areas was also more and more intensified in this stage. The mountainous terrain, which had not been fully developed, started to lay a clear road traffic network, and formed multiple secondary roads along the mountain terrain, laying the foundation for forming new mountain residential areas. Compared with the plan in 1933, the development of the areas of Palolo Valley and Kalihi Valley which were located in valley living groups, took on a new look, expanded and extending into the valley areas by a medium duty road that connects them with the downtown areas

of the city, and lots of secondary roads had been developed along the medium duty road, forming a number of new mountainous residential areas on different slopes at different heights. The areas of Pacific Heights and St.Louis Heights in mountainous living groups had also changed a lot compared with its plan in 1933: lots of secondary roads had been added, road networks had been intensified, different settlements were divided and more household units were accommodated. And for the original Nuuanu Valley, Manoa Valley, Alewa Heights and Maunalani Heights which had a certain degree of development of mountain settlements before, the residential density had also made a certain improvement, and more and more residents began to live in these areas now in addition to the continuous improvement and the increase of road networks.

By the end of the twentieth century, the development and utilization of the mountainous areas in Hawaii region and the development of the mountainous residences had already grown mature. The planning and construction of the mountainous settlements began to show intensive growth, and the central city would spread the entire residential industry throughout the mountain system. From the planning and development of Honolulu District, Hawaii of 1998 (See Appendix), we can see clearly, compared with the planning and development of 1953, the road classification of 1998 was more obvious, and the road planning of mountainous residential areas was more colorful. In Manoa Valley and Nuuanu Valley, two of the large valley regions, roads and networks were growing increasingly mature, while the dispersion and expansion of the secondary roads increased the mountainous residential space. In

Palolo Valley and Kalihi Valley, two narrow valley strips, the road planning presented the trend of a straight line extension, expanding the scope of the living areas. While in the five mountainous regions, road plans had increased a lot, but in general it was still similar to the planning and development trends of 1953.

4.2 The relationship between the development of mountainous residential planning and road traffic in Hawaii (after the existence of power vehicles)

In the nineteenth century, due to the restrictions of traffic technology, Hawaii's urban planning and residential development were mostly confined to the terrain of the mountains. Although the carriage provided a new breakthrough to the Hawaii traffic technology at that time, it still had a considerable degree of difficulty and limitations in travelling long distances and passing mountainous areas. But at this stage, there were some road traffic planning in the valley areas, the development and utilization of mountainous areas and the modes of taking it as the new residential space has begun to emerge.

Entering the 20th century, with the introduction and development of industry, the mode of transport in Hawaii has changed greatly. In 1900, the introduction of the first batch of motor vehicles and trams make a new direction for the development of urban and residential areas. The planning and development of the mountainous residences in Hawaii area has become closely

related to road traffic. Some valleys and mountain areas, which were hard to reach in the past, have gradually developed, so that people can easily reach the downtown areas from the valleys and mountain slopes. As a result, because of the objective conditions of abundant rainfall and fresh cool winds in the valley, people are more willing and more ready to move their houses to the undeveloped valleys and the mountains, and finally form a new type of mountain residential area.

With the influence of the expansion of urbanization in Honolulu region, the utilization and development of mountain areas is now put on the agenda to meet the expanding population and the increasing demand for housing units under the premise of the popularization of automobiles. Urban planners plan urban residential areas in several major mountain terrains (including valleys and mountain slopes), increasing the planning and construction of urban roads in the mountain areas. According to the characteristics and conditions of the mountains, they create independent residential areas with a low level layout, forming the situation of spreading the slopes of the mountains. It increases the living space and expands the urban areas, making better use of the advantages of the mountain terrains. From the previous several pictures of the development of urban planning in different periods, we can see in a macroscopic view that in different stages, the urban roads are becoming increasingly clearer and more complex, road networks for the planning of mountainous areas, such as valleys and mountains, are becoming more mature as time goes by, and more residential communities are formed in the areas surrounded by roads. The

original agricultural areas are gradually replaced by the residential areas, more and more detached houses appear in the valleys and the mountain slopes where there was originally only agriculture, and now people use the connection of the grid roads to expand them as part of the urban areas.

In general, the introduction of motor vehicles and trams, not only has reformed the roads of city blocks, but has also increased the development of urban areas. On the one hand, it has strengthened the link between urban areas; on the other hand, it also has laid the foundation for the extension of the city and the development and utilization of the mountainous region. Meanwhile, the gradual increase of mountain road development brought by the development of the road traffic, regional roads are more intensive, creating the conditions for promoting the construction and development of the whole mountainous residential buildings in Hawaii, making it possible for people to live in the mountains.

4.3 General situation of the mountain areas and residences in mountainous areas in current Oahu, Hawaii, USA

As the only U.S. island state located in the Central Pacific Ocean, Hawaii is composed of 132 islands covering a land area of 1,6700 square kilometers. Its urban population accounts for 86.5% of the total, while Oahu, "The Gathering Place," the third largest of the Hawaiian Islands, is home to about 80% of the population. Honolulu,

the state capital, also known to some Chinese as "Tanxiangshan(檀香山)", is on Oahu's

southeast coast. The climate is typical for an island in the tropical zone, with trade winds throughout the year while its annual temperature is about 26 degrees centigrade to 31 degrees centigrade.

The Hawaiian Islands, which were formed by volcanic eruption, include 8 big islands and 124 small islands, stretching 2,450 kilometers, creating the formation of a crescent island chain. There are 2 active volcanoes on Hawaii Island, the largest island of the state. The climate is warm and pleasant all the year round and almost 50% its land area is covered with forests. However, influenced by its topography, the precipitations over the region vary differently from place to place. The state, which is mainly made up of nineteen major islands and coral reefs, lies in the Central Pacific.

At the "crossroads" of the Pacific, Hawaii, which plays the role of a hub between the sea and air transport between Asia, America and Oceania, occupies a

vital strategic position, of which Honolulu is a trunk line and an important port of the Pacific route. The highways here are very advanced though the number of railways is pitifully small. Pearl Harbor is home to the United States Pacific Fleet base and its headquarters. The federal government's defense spending is the state's biggest economic source, second only to the economic revenues of its tourism. Oahu is a concentrated area of industrial and agricultural production while Honolulu, located on the southeast coast of the island, is the largest political, economic and cultural center of the whole state.

4.3.1 Preview of geological and topographical conditions in Hawaii's Oahu region

4.3.1.1 Preview of geographical conditions in Hawaii's Oahu region

The Hawaii Islands joined the United States of America as a state in 1959. Its capital seat is located in Honolulu of Oahu Island.

Oahu has a total area of 1545.34 square kilometers, and its total length of coastline reaches 112 miles. Only in terms of area, Oahu is Hawaii's third largest island, also the most modern island in Hawaii. Oahu used to be the gathering place of the kings from different islands as well as a place where Western and Eastern cultures and races integrated in ancient times. Military supplies, tourism, pineapples and sugar are the pillars for its important economic projects.

The seat of the capital of Hawaii, Honolulu, also called Tanxiangshan to some Chinese, is located in the southeast coast of the island, and Honolulu

International Airport is also located in Oahu. If the areas of Ford island and other small-sized islands as well as the southeast coast (windward side) and the small islands of Kaneohe Bay are included, then the total area of Oahu reaches 1,545.4 square kilometers (roughly 596.7 square miles), making Oahu the 20th largest island in the United States. Together with the other islands in the Hawaii islands, Oahu is the northernmost as well as one of the largest islands in areas in the whole of Polynesia. (Fig. 4.3/4.4)

Fig. 4.3/4.4 Oahu Island and Honolulu
Source: Author

Population

Oahu is the most populous island in the Hawaii islands as well as the cultural and economic centre of Hawaii. Its total population is about 97,6199, of whom 72% are permanent residents, and about 81% of the population live on the side of the island which is called the "urban" area. Oahu has long been known as “the Gathering Isle.”

Climate

December and January are the coldest months, and the average temperature in the afternoon every winter is about 75 degrees Fahrenheit (roughly 23.89 centigrade). The hottest temperatures in August and September are more than 90 degrees Fahrenheit (roughly 32.2 centigrade). The average temperature is between 75 and 85 degrees Fahrenheit (roughly 29.4 centigrade). Due to the main trade winds, its rainfall is mainly concentrated in the northern and northeastern parts of the coast, while the southern and southeastern coasts, including Honolulu and Waikiki, are relatively dry.

4.3.1.2 Preview of the terrain conditions in Hawaii's Oahu region

Oahu is divided into seven administrative districts all together, and Honolulu, the capital of the state, is located in the southeast. There are two mountain ranges running from southeast to northwest on the island, with groups of mountain peaks towering into the sky. The altitude of the Koolau Mountain, the highest peak in Oahu, whose hilltop is flat, reaches up to 4,025 feet (roughly 1,220 meters) above sea level. The coast twists and turns, with a lot of coral reefs on the coast. The 69 beaches, of which 19 provide first aid, are all white.

From the topographic map posted on the official website of the state government of Hawaii, we can see that, the parts surrounded by green lines are of middle- and upper- level elevation of the two mountain ranges, representing forest reserve lines. Its lowest altitude is more than 900 feet (300 meters). The part surrounded by the red lines are divided into administrative districts and we can

see that clearly, Honolulu District, compared to the other six districts, is densely covered with square grids, representing the city roads, and points standing for the buildings, and etc. This fully illustrates the importance of Honolulu as the economic and cultural center of the seat of the state's government and the entire Hawaii's Oahu region. In addition, we can find that all the point marks representing the buildings are outside the scope of distribution of the green range. This also fully proves that no people live in the range of the region above the height of 900 feet (300 meters),and the area belongs to a specific area of forest reserves.

4.3.2 General Introduction of land use in the Oahu region of Hawaii

4.3.2.1 Review of land use in the Oahu region of Hawaii

By searching for Oahu land use (1998)(Land Use on the Island of Oahu, Hawaii, 1998), we can find that the establishment of its National Water-Quality Assessment program(NAWQA)of the U.S. Geological Survey(USGS) aims to evaluate the situation of ground and underground water resources and the developmental trend of the water quality in the Oahu region of Hawaii. However, land use is one of the most influential human activities that affect the quality of hydrology and natural resources in Hawaii. Land use changes the modes of drainage pipes and infiltration, changes the vegetation, and increases the physical and chemical compounds, which directly affects the hydrological quality.

For the management of natural and cultural resources, the spatial

distributional pattern of land use and the information of the corresponding changes are very important. For example, the management of soil and agricultural resources needs to be conducted under the control and establishment of the corresponding land resources. On the chart of land use, water quality conditions need to be compared in similar or different land use basins (or watersheds). And for the future of agriculture and urban development, it is also necessary to be implemented in currently available land, trends and resources allocation management data. In Hawaiian daily life, there is a great gap between the intensity of land use and the extent of land use. Land use patterns reflect the impact of diversification, including land owners, available water resources, and the geological conditions of the soil as well as economic opportunities.

The terrain of the Oahu region of Hawaii provides the background of the coexistence and differences for land use. For example, the traditional agriculture as a means of subsistence can be developed just adjacent to industrial or tourist areas. In addition, due to the tropical location of Hawaii in the Pacific Ocean, many land use practices tend to be specialized, such as hybrid corn crop rotation research three to four times a year and ginger planted land lease lent to minimize the infestation of nematodes by about five years at a time. Recently, land use in Hawaii has been changing rapidly, particularly in terms of urban and rural development and expansion and diversified agricultural cultivation, and these changes has taken place in the land use of the previous sugar industry and pineapple farming.

4.3.2.2 Classification of land use in the Oahu region, Hawaii

To support the U.S. Geological Survey's National Water-Quality Assessment program (the same as above USGS, NAWQA), Land Use on the Island of Oahu (1998) lists a series of hierarchical land use classification system. We can get the data from the following chart.

From Fig 4.5, we can see that Oahu land use is divided into four types, which are agricultural land, urban construction land, barren land (mining land) and other lands. Of them, the yellow part stands for agricultural land, which covers an area of 5,9195 acres, accounting for 15.4% of the total; pink stands for urban construction land, which covers an area of 9,8663 acres, accounting for 25.7% of the total; blue stands for barren land (mining land), which covers an area of 1,522 acres, accounting for 0.4% of the total; green stands for other lands, including the forest reserves, natural reserves, wetlands, water bodies, rocky sandy lands and undeveloped plant areas, covering an area of 22,4331 acres, making up 58.5% of the total area. From the picture, we can see that most of the agricultural land is located in the middle hinterland of Koolau Mountain Range and Waianae Mountain Range in the northwest of Oahu and the relatively flat slopes in the Southwest of Oahu. Most of urban construction land is located in the southeast of Oahu, especially the urban construction of flat land areas and slope land areas in the capital region of Honolulu. Its urban construction dwarfs other regions, because it is the economic and cultural center of Hawaii. There is relatively little barren land (mining land), which are sparsely distributed here and there in every corner of

Oahu Island, while the largest proportion of other land use demonstrates the terrain and geographical conditions and characteristics of Oahu. This part is mainly composed of forests and nature reserves, namely the mountain range in the upper reaches of the mountain range, where it does not involve any artificial transformation of land and land use classification.

In urban construction land, however, we can divide land property into six different categories according to their different functions, which are commerce, industrial manufacture, open land, public infrastructure, residential areas and social services. Of them, the residential land covers an area of 4,4905 acres, accounting for 22.8% of urban construction land. From Fig. 18 we can see the distribution and trend of the construction of the regional city of Oahu in Hawaii: The main city construction is located in the Honolulu District, the capital of the state of Hawaii, where the coastal part focuses on the development of commercial and public service facilities and the number of people living coastal areas is relatively smaller. As Hawaii is a hotspot as a resort for tourism industry, the residential land is mainly distributed at the foot of the Koolau Mountain Range and on mountain slopes, going continuously up along the trend of the watershed. The reason for such a distribution is that the terrain of the coastal areas, which is relatively flat, boasts excellent coastal scenery.

So, the relatively flat terrain region of Hawaii, as a tourism- oriented resort for economic and cultural development, well deserve the title for the development of commercial and economic culture, while the residential land,

which depends on business and so on, retreat into the hinterland of the mountain range and the mountain slopes. Because Hawaii is very experienced at its residential construction on mountain slopes and in mountain areas, most of its buildings are detached houses (to be mentioned in the next section), there is no special difficulty in the construction of buildings on sloping land, so residential building are mainly distributed here. In addition, the watersheds of the mountain range are irregularly distributed, so houses built along the watersheds can have more access to natural water resources, which provides a great convenience for people's life.

Fig. 4.5 Land use of Oahu Island
Source: Land use on island of Oahu, Hawaii, 1998

Fig. 4.6 Land use of Oahu Island
Source: Land use on island of Oahu, Hawaii, 1998

4.4 The Development of Modern Planning of Hillside Residences and Mountain Utilization and Their Characteristics in China

4.4.1 Modern Planning and Development of Hillside Residences in China

In modern sense, the construction of the Chinese settlements began in the 1950s. At that time, the residential areas advocated the concept of "unit compound" rather than the "miniature community" concept in the Soviet Union. It was a new type of residential space construction, which was completely different from the traditional city mainly composed of neighborhoods, residential areas, workshops and business areas. Respective public facilities were equipped in residential areas of different levels, such as canteens, hospitals, shops and health clinics, to meet the public's life needs within the area with self-sufficient residents all having the same social identity. Therefore, generally speaking, these residential areas all have their own independent management styles, and separated themselves from the outside society with something such as a wall, and this was the ubiquitous residential areas' pattern in China's cities in the 20th century, known as the "unit compound."

In the mountainous areas of the Southwestern region in our country, the settlement pattern of this form is significantly different from most cities on the plains as a result of the constraints of the land utilizing conditions of mountainous areas: many "units," like factories, and public institutions, must choose relatively even and open marginal areas in the city or remote

mountainous areas for construction, which makes it possible for the residents in Southwest mountain cities to retain its original living space and original living mode to a great degree. Even small adjustments, new construction and some renewal in a unit's internal functions should fit in with the status of the "unit" , and the typical features of this period are still characterized by its vague and free-styled form of partition, as well as its close relationship with the natural environment. Certainly, at this time, the public facilities were not yet perfect and the general situation of public space buildings in the residential areas was not attached great importance to. Moreover, the situation was even more serious in mountainous areas, especially in the old city, for the narrow, winding street spaces at different heights almost assumed all the meanings of public venues for the residential areas.

Since the 1980s, the welfare-oriented public housing distribution system within the unit has been gradually canceled, kicking off the prelude to the reform of the housing system. 30 years later, China has experienced the most turbulent period of urban residential construction. The gradually-formed national housing reform policy over the past 30 years has played an important role in improving the speed of the construction of urban settlements in mountainous areas.

With the rapid development of China's economy and technology, the real estate industry has gradually developed from the initial small step of collecting a small amount of rent, to selling the houses to their residents with subsidies, to the current consumer- oriented apartments and houses catering to different income

levels, which better suits modern people's living needs.

Different from traditional Dry Lanna-style residences and the mountain residences before commercial development, China's mountain residential development, after the housing policy reform, has formed a unique mountain housing construction atmosphere in planning and design as well as the exploitation of new technologies. It has also brought about some new problems. Here, the development and construction of the "mountain city" Chongqing is taken as a typical case.

With the Great Development of the West, the population displacement of the Three Gorges and the large-scale migration of urban residents, Chongqing's residential development, together with the construction of the city has entered a new era of development: tall buildings, hotels, apartments, office buildings can be found everywhere in Yuzhong Peninsula, just like "Manhattan" in southwestern China; along the Yangtze River and the Jialing River, as well as their nearby banks, speed highways and interchange bridges over the rivers have been newly built; besides, light rail lines are open to traffic; river-crossing tunnels are under planning; a full range of fast traffic measures such as water buses is emerging; all of these help to have a large number of new residential projects launched one after another on the two rivers and three banks. The overall development of the city has led to the expansion of the community and has become a solid foundation and impetus for the development of mountain dwellings. In recent years, therefore, the development and construction of mountainous residential buildings in Chongqing have topped the list in local real estate industry-related investment. (Fig. 4.7/4.8)

Fig. 4.7 2008 Chongqing local real estate Investment

Source: <A Preliminary Study on the Design Strategy of Low-rise Housing in Mountainous Areas>

Fig. 4.8 2009 Chongqing local real estate Investment

Source: <A Preliminary Study on the Design Strategy of Low-rise Housing in Mountainous Areas>

In addition, taking Chongqing region as an example, in the process of contemporary mountain housing development, the level of housing can be divided into four categories (Fig. 4.9) in order of the number of storeys in turn: multi-storey residences, high-rise residences, high-end apartments, and low-rise

Fig. 4.9 Four categories of housing
Source: Author edit

dwellings. It can be seen that as far as the developing strength of China's contemporary mountain residences is concerned, the proportion of high-density, multi-storey and high-rise residential buildings is relatively large, while the low-rise residential buildings are relatively few.

4.4.2 The Problems of Domestic Contemporary Mountain Utilization

Of China's contemporary mountain problems, land use is an important social and economic one. At present, the severe situation of land use in our country is: the absolute quantity of land is large whereas the quantity per capita is very small. This is also related to the development process of mountain residences as previously mentioned. The developers tend to build high-density, multi- and high-rise residences, resulting in a small amount of land possession per capita. In addition, as far as territorial resources are concerned, there are fewer and fewer usable land resources, whether it is for agriculture or construction. Therefore, the effective use of existing land resources has become a thorny issue.

But in the process of current mountain development in China, large-scale land leveling, urban demolition, as well as extensive, large-scale and huge volumes of modern buildings' construction, have changed the harmonious relationship between the mountain areas and the natural environment, driving

the traditional urban textures almost to extinction in order to reap fast track business interests and meet the requirements of the speed of planning and construction. However, it often leads to irreconcilable contradictions and conflicts between the old and new. On the planning and design level, there is no full consideration of the characteristics of mountains and the effective use of terrain elevation in many construction projects, resulting in a waste of land resources.

4.4.3 The Characteristics of the Development of Contemporary Residential Planning in Mountain Areas in China

1) Invasion-oriented mountain planning and construction

With the need for economic development and the rapid increase in the demand for living space since the reform and opening up policy was implemented 30 years ago, large-scale land leveling, the demolition of the old city and extensive, large scale and volume of modern residential invasive construction, have become one of the main characteristics of the development of contemporary residential planning in mountain areas. In the current mountain residential construction, we can often see the mixed layout between the old city and the new city, which demonstrates that there is no integrity. (Fig. 4.10/4.11, 4.12/4.13)

Fig. 4.10 Old housing community
Source: Author edit

Fig. 4.11 New housing community
Source: Author edit

Fig. 4.12 Old housing community
Source: Author edit

Fig. 4.13 New housing community
Source: Author edit

2) Generalization of residential layout

Up to now, the development of many mountain residential areas in China still follow the “three connections and one leveling” model, namely, “water connection”, “electricity connection ”, “transport connection” and “ground leveling”, copying the layout pattern of flat residential design, which draws a whole flat range on the planning and construction of the mountain area. On the basis of the construction then, especially for the lower slope of the land, it often eradicates the original natural landform and chisels a lot, due to which the mountain has lost its original ecological style, and it has also destroyed ecology, creating potential natural disasters; whereeas on the higher slope, it often simply uses one or more large platform for processing, which at the same time causes great destruction to the ecological slope. It does not use

the form of mountain height differences to the layout of the residential model, wasting a lot of land resources, and ignoring the ecological and environmental benefits. (Fig. 4.14)

Fig. 4.14 Residential Layout in some estate of Chongqing

Source: <A Preliminary Study on the Design Strategy of Low-rise Housing in Mountainous Areas

3)Discrete public and road space textures

Due to the huge amount of construction, as well as the invasion of the leading planning and construction, the closed modern honeycomb in the Southwest mountain cities has been invaded, forming invasive places, so the original micro textures of mountain city space has been greatly changed, making up a contemporary discrete mountain city residential area public and road space. Due to the closed management of the community, the orientation of the segmentation is formed between the living space, that is, the differences of the public quality between residential areas have increased and the isolation in the external space is strengthened, and the isolation of space can accelerate the emergence of social polarization. Especially in the old city, with some new mountain residential areas to join it, it has destroyed the original urban living space textures, and also interrupted the possibility of urban context in the continuation of the living space.

4.5 The Comparison of the similarities and differences of hillside residential modern planning and development between Hawaii and China

Differences

Promoting mechanism of land use

The development of modern planning on the hills of Hawaii seems to be in favor of the development of the region as a whole, spreading from the plains to the hillsides. The land use development mechanism of the mountain is mainly based on the development of road traffic as the main line, “the road goes before a house”; residential areas extend along the road in the form of groups, maintaining consistency and continuity with the road and residential areas development as a whole. Therefore, the land use and development of Hawaii mountainous areas are guided by the development of urban roads.

In our country, the development of modern hillside residential planning mainly relies on the regional development of the city for advancement. Its invasive new mountain residential areas in patchy form spread in the urban mountain areas, mixing themselves with the old city and the traditional mountainous residential areas. The mechanism of land use mainly depends on the city’s overall planning and development direction to promote.

Planning construction mode

As the residences are spreading in every direction as a whole, when designers plan the hillside residences and the roads in Hawaii, the United States, they will give more consideration to the characteristics of the land forms, and arrange the

mountain residential location and its overall layout as far as they can according to the mountain heights and its ecological environment, for this approach is more conducive to the effective use of land. In addition, in Hawaii hillside residences, almost all of the mountain houses are low-rise town houses or rows of low-rise multi-storey semi- detached residential houses; seldom can we see high-rise residential apartment buildings, as such a practice is also a kind of protection of the mountain soil and structure.

But in the modern hillside residential planning and development in China, more is in the construction form to imitate the ground of large-scale demolition and construction, shovel the landform for a planned residential area, or build a large platform, on the basis to carry out the construction and layout of the ground. Besides, more high-rise apartment residential buildings are being developed, while very few low-rise residential houses can be seen. Although this approach can accommodate more people, it does great damage to the land and the environment. Moreover, as it is by no means an effective use of land resources structure combined with the landscape layout, to some extent, it is also a waste of land resources.

Similarities

Mountain utilization pattern

In the layout pattern of mountain utilization, both have something in common, that is, a multi-center group layout. This layout pattern is very effective from the perspective of mountain use and its residential planning, which can effectively

combine the characteristics of mountain land resources in the layout, making the mountain, rivers and slow slope green belts a separation zone for the group, so as to make use of the characteristics of natural mountain terrains, and improve the living quality of the mountain city.

In addition, each group can be equipped with a moderate scale of support facilities and public facilities, which can meet the daily needs of the masses within the group, and reduce the needs of travel across groups. It is also an important layout of the low- carbon concept of living lifestyle.

4.6 Summary

This chapter focuses on a comparison of the modern planning and development of mountain residential areas between Hawaii and China. The main feature of this characteristic is the increase in mobile traffic, the gradual construction of mountain roads, and the gradual increase in residential space. This chapter describes the different developmental characteristics and common similarities between the two in the development of modern planning.

In the process of the development in modern planning and hillside residences in Hawaii, this chapter mainly studies the changes of the urban roads in the Oahu Lake Region of Hawaii and the changes in residential space in the mountainous areas, and analyzes the impact of the emergence of motorized vehicles on the mountain roads in the Hawaii area, and its relationship with the hillside residential development through the analysis of the urban planning in the 100 years since the occurrence of the means of motorized transport.

In the process of the historical development of hillside residences and the modern development of the Mountain utilization, this chapter mainly analyzes the development of China's residential areas in the 20th century, taking the mountain city of Chongqing as an example, to study the development of contemporary mountainous residential buildings in our country and points out the problems of contemporary mountainous land use: many mountain towns simply imitate the model of plain construction blindly, ignoring the mountains, rivers, natural scenery, landscape, special places of historical and cultural interest, in blind pursuit of the construction of newer, larger buildings at an ever faster speed while paying inadequate attention to the traditional mountain space. The reason behind it is that on the one hand, under the new technical conditions it is unavoidable to be affected by the modern life styles; on the other hand, in the process of rapid construction, the pursuit of maximization of capital profits within a short period of time, in many cases, cannot be avoided, for politicians often compete to pursue the grand style with their modern city counterparts on the plains because they are also eager for more political feats.

Finally, comparing the differences between the promoting mechanism of land use and the planning and construction model, we can summarize the similarities of the two groups in their use of mountainous land to arrange their groups of residential buildings.

CHAPTER 5 | COMPARISON OF THE DESIGN NORMS FOR MOUNTAIN RESIDENTIAL BUILDINGS IN HAWAII AND IN CHINA

5.1 Residential types and residential land partitions in Oahu, Hawaii

5.1.1 Housing types in Oahu area, Hawaii

In Hawaii's residential system, like the rest of the United States, residential buildings are generally divided into three categories.

The first category is the Single Family House, also called the independent villa or independent house. In Hawaii, such a residence is the most popular, and each residence takes up a Lot of its own. The villas on different Lots are in a variety of sizes, and they can be bungalow, or two or three-storey buildings. There is hardly any mid-rise, high- rise or super-high-rise buildings here. Usually, there is one to five or six rooms, or even more, mostly two to four rooms, a kitchen, and three to four bathrooms. Usually, there are storage rooms and garages, but the numbers may be different. An independent villa is usually surrounded with grass and gardens. One feature of the independent villa is that the property owner owns a fairly big piece of land and he has the exclusive right over the land and the villa. As independent residential property owners, all

things are up to the owners to decide so long as it doesn't affect others or the general public, from the exterior building style, to the courtyard's improvement and family living habits to the construction of gardens, swimming pools, tennis courts, raising pets and so on. Of course, the owners have to cover the full costs of housing repair and maintenance. Single Family Houses are usually suitable for property owners to buy for themselves, for they can create their own dream home according to personal preferences.

The second category is the Townhouse or semi-detached house. Townhouses are arranged in rows side by side, which means that their residences are completely independent of each other, but share public walls or gables with one or several neighbors. Each house has two to three floors, two to four rooms, one kitchen, one to three bathrooms. Each house has its own water and electricity completely independent of each other. The owners are allowed to buy one townhouse, but also can also buy more as long as they can afford to do so. Under normal circumstances, townhouses usually exist in a residential area which has been already designed, and there are some public green spaces and small gardens in each row unit of the residential area. The owner of each townhouse has the full ownership.

The third category is the apartment building. Apartment buildings are further divided into Condominiums, and Apartments. The differences lies in the fact that the owners of the former have independent property rights while those of the latter do not. In a sense, Condominiums are private properties, for their property rights belong to the owners, and each individual owner has the property

rights of its own unit, but does not have the property rights of the land. To be exact, the owner of a Condominium owns the space inside of his own unit, which is a bit like the commercial house in China. An Apartment is for rental, for all the property rights belong to a certain company and the company leases each unit to a different tenant. In addition to the monthly rent, the tenants may also cover the costs of garbage clean-up, property management, and the like.

5.1.2 Residential land zones in Oahu, Hawaii

In the Hawaii region, Land Use Ordinance (LUO) set rules for different zoning rules. Each zone has its own different rules, such as the nature of the land, the boundary line, and the height restrictions. Different zone systems include residential land zones, holiday tourism land zones, commercial land zones, industrial land zones, agricultural land zones and protection land zones. Each zone has its own classification, requirements and constraints.

In the residential land zones, land for independent residences and townhouses can be divided into five types, R3.5, R5, R7.5, R10, and R20 respectively. While R refers to Residential, the numbers that follow closely represent the smallest square feet in this category. To be exact, R3.5 indicates that the minimum land area is 3,500 square feet; R5 indicates that the minimum land area is 5,000 square feet; R7.5 indicates that the minimum land area is 7,500 square feet; R10 indicates that the minimum land area is 10,000 square feet; R20 indicates that the minimum land area is 20,000 square feet. Classifications of residential land regulate the requirements of housing

construction. Take R5 the nature land use for example: the total area of the land owner's residential building and its courtyard cannot exceed more than 5,000 square feet. For every 5,000 square feet of land in the R5 category, the owner of the land is allowed to build a house with a kitchen. Currently, there are some lands belonging to the R5 category, but their land area takes up less than 5,000 square feet. There is no problem for house construction, even if the distance is not set aside from the boundary line (Of course, it violates the boundary line rules of the housing land in Hawaii). If a piece of land is 7,500 square feet and the nature of land is R5, then the owner of the land can build a duplex residence with two kitchens; if the land nature of a piece of land is R5 and its land area is larger than 10,000 square feet, then the owner of the land will be able to build two adjacent independent houses, each with a standard kitchen. For a plot of land, the owner is entitled to have many options and choose the one he desires most. Although each piece of residential land has been specified in the nature of its land use before the housing construction, the owners are in a position to discuss with the registered architect the possibility to submit an application to the Honolulu regional government and modify the nature of its land to meet the needs of their households if the land owners want to extend their housing area,.

The land zones of R20 and R10 are usually developing regions of large plots. These areas are usually located in the far suburbs of city development, and exist as the transitional region of the city with suburban agricultural areas and forestry reserves. In the residential development of the city center, land zones are usually adopt the standards of R7.5, R5 and R3.5.

Fig. 5.1 Residential Districts Development Standards
Source: Land use ordinance of Hawaii

In residential land zones, however, residential land mainly for apartment-style housing can be divided into three categories: A-1, A-2, and A-3 respectively. A refers to Apartment, whereas the following number stands for density grade. A-1 stands for low density residential apartments' land zone, which usually refer to mid-high-rise apartment buildings with low density and multiple families, acting as middle buffer zones for independent residences and lands for other use. A-2 stands for middle density residential apartments' land zone, usually distributed in densely populated urban areas, with public service facilities and adequate infrastructure as their center. A-3 stands for high density residential apartments' land zone, mainly in the form of high-rise residential buildings, which are usually distributed in downtown areas with a wide range of public services and large infrastructure.

5.2 Design specifications of mountainous residential buildings in Hawaii

5.2.1 Entrance-exits along the road

All residences must be placed within the boundary line of the building plots and maintain a certain distance from other residential lands in the block. For each detached house and each residential unit of townhouses, its entrance-exit must be directly accessible to public pedestrian streets or public corridors, and pedestrian paths must not be less than three feet (1 meter) in width. For each apartment, its entrance-exit must also be connected to public streets and accessible to the pedestrians' pavements, which are supposed to be not less than 44 inches (1.17 meters) in width.

5.2.2 Courtyard space

The courtyard space of the house refers to the space between the exterior wall of the building with windows or the building to the vertical surface of the boundary of a plot. Its specifications need to meet the following requirements:

(a) For a house with a height of no more than 15 feet (<4.5 meters), its courtyard space should not be less than 5 feet (1.5 meters) in width.

(b) For a house with a height of no more than 25 feet (<7.6 meters), its courtyard space is required to first meet the basis of 5 feet in width, together with the part in excess of the height of 15 feet. It is supposed to calculate according to the standard of one foot of courtyard in space for every

two feet in height.

(c) For a house with a height of more than 25 feet (<7.6 meters), its courtyard space is required to meet the basis of 10 feet, together with the part in excess of the height of 25 feet. It is supposed to be calculated according to the standard of one foot of courtyard in space for every ten feet in height, and the maximum width of the space in the courtyard cannot exceed 20 feet (6 meters).

5.2.3 Section design (Residential height)

In Hawaii's mountainous residential planning and design, the control of the section design of detached houses (residential height) is very strict. According to the requirements of the local regulations of Hawaii, the construction height of the detached house must be controlled within 25 feet (7.6 meters). As a result of different mountain terrains, the profile designs of the residential building and the contour line of the residential construction vary from one to another. The top contour lines of the house and the height of the building are determined by the intersection of the two planes. The first plane is Plane A, which is determined by the plane of the fixed point on the basis of the horizontal direction while the fixed point at the height of 25 feet in a vertical direction at the highest point of the building block. The second plane is Plane B, which, parallel to the terrain, is 30 feet (9.1 meters) above the surrounding areas. According to different terrains, the two planes can form different cross forms or parallel forms, thus forming the

residential profile contour lines and residential construction heights. And the contour lines around the house are determined by the height of the residence: If the height of the back wall in the backyard of the house is more than 15 feet high, then for the part in excess of the height of 15 feet of the house, one foot backward inside is required for the increase of every 2 feet in residential height (i.e. its height-width ratio is 2:1),which finally forms a slope back line and intersects with the top contour lines; if the height of the front wall in the foreyard of the house is more than 20 feet high, then for the part in excess of the height of 20 feet of the house, one foot backward inside is required for the increase of every 2 feet in residential height (i.e. its height-width ratio is 2:1),which finally forms a slope back line and intersects with the top contour lines. Therefore, the profile designs of the detached houses and its buildable contour lines can be divided into the following two types:

The first type is in the plain or in gentle sloping area. As the terrain is relatively even, the fixed point Plane A, which is 25-feet high, and Plane B, which is 30 feet higher than its parallel terrain, are parallel to each other. If so, take Plane A as the greatest height contour line of the residential construction, and intersect with the sloping back line of the contour line, forming the residential section design of the plain and gentle sloping area as shown in Fig.5.2

The second type is on mountain slopes or in mountain areas, because the terrain slope and elevation are obvious, the fixed point Plane A, which is 25-feet high, and Plane B, which is 30 feet higher than its parallel terrain, intersect and form a residential building height contour line, and intersect with the slope back line of the contour line, forming a residential section design of a mountain slope and a mountainous area as shown in Fig.5.3.

The two practices both keep 10 feet (3 meters) of courtyard space in the front yard, and 5 feet (1.5 meters) of courtyard space in the back yard, and adjacent to the street space. The largest construction area is 50% of the land area.

Fig. 5.3 Resident height control
Source: Land use ordinance of Hawaii

5.3 Categories and classification of China's residential land

5.3.1 Classification of China's residential land

According to the stipulations in China's "*Code for Classification of Urban Land Use and Planning Standards of Development Land*", residential land can be divided into four categories: R1 refers to first-category residential land; R2 refers to second- category residential land; R3 refers third-category residential land, while R4 refers fourth-category residential land. Of them, R1 refers to the first-category residential land where municipal public facilities are well equipped, with a self-contained layout, good environment, and mainly low-rise or mid-rise residences; R2 refers to the second- category residential land where municipal public facilities are well equipped, with a self-contained layout,

fairly good environment, and mainly mid-high-rise or high-rise residences; R3 refers to the third-category residential land where municipal public facilities are not so well equipped, with an incomplete layout, acceptable environment, or residential land mixed with industrial land and other lands; R4 refers to the fourth- category residential land where people mainly live in modest residences.

5.3.2 The grading scale of China's residential areas

In order to ensure the basic living environment for residents, and make use of land and space economically, rationally and effectively, "*Code of urban Residential Areas Planning & Design*" divides residential areas into three controlled scales, residential communities, residential areas, and residential groups respectively, according to the numbers of the households or the sizes of population. To be more specific, the number of households of a residential community ranges from 10,000 to 16,000; the number of households in a residential area is about 3,000-5,000 households; the number of households for a group is 300-1,000. The layout of a residential community can adopt the form of the residential community–the residential area - the residential group; the residential area - the residential group; or independent groups, etc.

Fig. 5.4 Grading Scale of China's residential areas
Source: *Code of urban Residential Areas Planning & Design*

5.3.3 Residential areas balance control index

"*Code of urban Residential Areas Planning & Design*" set the balance control index for the land use for the residential area. As for the tract housing development, residential communities, residential areas and residential groups have different land compositions; the more people a residential place is capable of accommodate, the less residential land it takes up, the more space it means for the roads and public green land.

Fig. 5.5 Residential area balance control index
Source: *Code of urban Residential Areas Planning & Design*

5.3.4 Residential land development intensity

The development of residential land in our country needs to control the population density and building density, and make sound decisions as for the intensity of land development. Chongqing City, for example, "Chongqing City Planning and Management Technical Regulations" pointed out that, in the process meeting the goal of building Chongqing into a "livable city" and "a garden city with mountains and water", there is such a problem and tendency

to increase the floor area ratio blindly in order to reap more economic benefits as to overlook the quality of residential environment in the current development process of residential land in Chongqing, so the have drafted strict standards to control the intensity of urban residential development, and improve the quality of residential environment. According to this index table, the building density is stable, ranging between 30% and 40%, and the floor area ratio ranges between 1.0 and 3.0 whether it is in an old city renewal area or in a planned new area,.

5.4 Code for Planning and Designing China's Mountain Residences

5.4.1Road system design

In order to make full use of space, expand the living space, and facilitate the activities of the residents to travel, the creation of an overall residential area road planning system fits in with the growing needs of the people living in mountain residences. According to the corresponding regulations on road design of the "Code of urban Residential Areas Planning & Design," the setting of roads in mountainous residential areas should generally meets the following provisions.

1. Lanes and sidewalks should be set apart as self-contained systems;

2. Road network formats should be placed according to local conditions;

3. The main roads should be even;

4. The road may be narrowed as appropriate, but the necessary drainage ditch and parking spaces should be arranged and should comply with the relevant provisions of the local urban planning administrative department.According to the three categories of residential places in China, the region's internal roads are also divided into three categories: residential area roads, residential community roads, and residential group roads. According to these three different places, roads can also be subdivided in accordance with their corresponding measures as follows.

1. Residential area roads: red lines should not be less than 20M in width;

Residential community roads: 6-9M in width;

Group roads: 3-5M in width.

2. Paths between houses: should not be less than 2.5M in width

3.The main roads in a residential community should have at least two entrances; the main roads in the residential area should have at least two directions connected to the external roads; the distance between the motorway entrances should not be less than 150M in width; pedestrian exit spacing should not exceed 80M in width.

4. When a residential area road is connected with an urban road, then the angle of them should not be less than 75 degrees, and it is preferable to use adopt the

method of right angle intersection traffic organization; when the road slope in a residential area road is relatively steep, a buffer section must be set up to connect itself with the urban road; in the practical application to mountain regions, such as Chongqing, for example, it is prescribed in the provisions that when residential roads and urban roads cross each other, the angle should not be less than 70 degrees for the terrain is so complex there. When the crossing angle of the road is beyond the above range, the flat curve can be added to the exit section of the residential road to meet the requirements.

5. The road to enter a residential group should be convenient for residents to travel, the passage of fire engines, and ambulances, and also to maintain the integrity of the courtyard as well as safety and security;

5.4.2 Vertical planning section design

"Code of Urban Residential Areas Planning & Design" stipulates that in the residential areas in our country, the design of vertical planning mainly needs to take into account the index of longitudinal slope control in residential areas. According to the regulations, the maximum longitudinal slope of motorways and walkways should not exceed 8.0%; the maximum longitudinal slope of non-motorized lanes should not exceed 3.0%; and the minimum longitudinal slopes must be greater than 0.2%. The mixed roads of motor vehicles and non-motor vehicles, the longitudinal slope should be based on the requirements of non-motorized vehicles, or subsections according to non-motor

vehicle lane requirements control. When the residential area road longitudinal slope is above 8% and the slope is more than 30M in length, a ladder roadway must be provided.

However, in the practical application of mountain practice, according to the limitations of mountainous terrains and the consideration of the present situation, the interior city has made some corresponding adjustments. Chongqing City, for example, according to years of determination practice, the residential road motor vehicle maximum slope adjustment should not exceed 12%, increased by 4% compared with the national standard, and the minimum longitudinal slope must be greater than 0.5%; And as for the pedestrian level, note that when the slope is steep, the major walking slope can be adjusted to 10%, and the minor walking slope is adjusted to 15%.

In addition, it is preferable for the longitudinal slope of motor lanes, non-motorized lanes and sidewalks in residential areas to be 1% -2%.

Fig. 5.6 Vertical planning section design
Source: *Code of urban Residential Areas Planning & Design*

5.4.3 Transitional space between the edge of the road and the house

Usually, green belts are used as transition spaces (public spaces) between roads and buildings in the area. The minimum distance from the edge of the road to the building in the residential area shall comply with the following requirements.

1. **If the building faces the road, there are two cases as follows:**

a) There are entrances: the minimum distance of the transition space in the district is 5M, while the minimum distance in the group is 2.5M;

b) There are no entrances: in the high-rise residential areas, communities, groups these three categories, the minimum distances are 5M, 3M, and 2M, respectively. Of the three categories of multi-storey residential areas, residential communities, and residential groups, the minimum distance of residential areas is 3M, where the data for the other two remain unchanged.

2. **If the building's gable faces the road, then there are two subtypes:**

a) High-rise buildings: in the residential areas, residential communities, and residential groups, the minimum distances are 4M, 2M, and 1.5M, respectively

b) Multi-storey buildings: in the residential areas, residential communities, and residential groups, the minimum distances are 2M, 2M, and 1.5M, respectively.

3. However, the minimum distance from the outer wall of the road to the outside world is 1.5M for all the three categories.

Fig. 5.7 Transitional space between the edge of the road and the house
Source: *Code of urban Residential Areas Planning & Design*

5.5 Summary

This chapter mainly discusses the categories, classification and planning design of hillside residential land in Hawaii and in our country, and summarizes the several typical directions of the differences, coming to the conclusion that some of the China's internal norms can draw a lot from the norms of Hawaii.

As for of Hawaii, this chapter first discusses the residential categories and land zoning of the Hawaii mountainous residential system, and points out that

Hawaii's residential land can be divided into five categories in terms its mountain land use, and the pattern is that the houses are mainly single detached ones which form a residential group. Then, the thesis examines the planning and design specifications of the residential mountain buildings in Hawaii, conducting a planning level analysis of the characteristics of the residential mountain groups from the aspects of road design, courtyard space and planning section (residential height).

As far as the part about China is concerned, this chapter discusses the classification of the fourth-category residential land and the scale of the land zoning of the third- category residential land in our country, which is clearly different from the classification of mountainous residential areas in Hawaii. Then, this chapter explores the strength of mountain residential development in China. Then, in terms of the China's hillside residential planning and design specifications, this chapter mainly studies the normative practices of the planning of China's mountainous residential design from the aspects of road system design, vertical planning profile design and the transition space between the road edge and the house, with the mountain city of Chongqing as an example.

Finally, since the norms of mountainous housing in China are not comprehensive in some aspects, by comparing the similarities and differences between the two, this chapter will enable people concerned to exploit the design specifications of Hawaii, which is of some reference value for the China's hillside residential planning and design specifications.

CHAPTER 6 | CASE STUDY OF THE PRACTICS AND CHARACTERISTICS OF SLOPING LAND AND MOUNTAINOUS RESIDENCES IN OAHU REGION, HAWAII

6.1 Preview of research objects

In the Oahu region of Hawaii, the characteristics of the distribution of residences have a close and direct connection with their geographical position and topographical features. In a relatively flat plain, due to the good terrain, pile foundations can be easily buried deep underground. Besides, as a result of the high population mobility of the residential population in the plain areas of the Honolulu region's economic and cultural center, so there are more middle to high-rise residential apartment buildings. And for the slopes at the foot of the Koolau Mountain Range, the residential buildings mainly exist in the forms of detached houses and rows of semi-detached houses, while residences in higher residential areas on the mountain slopes demonstrate a variety of flexible forms and sizes as the construction of rows of semi-detached houses and middle to high-rise residential apartment buildings prove more and more challenging. Comparatively speaking, it is a little easier to build the detached houses at a variety of altitudes on the slopes of the mountain slopes.

The mountainous residences on the mountain slopes of Oahu region of

Hawaii have their own unique way of construction and design features. In order to better explore and understand the design method and characteristics of sloping land and mountainous residential areas in Oahu, Hawaii, the author himself is fortunate enough to have conducted a one-month field investigation in September 2016 in the Oahu region of Hawaii by virtue of a dual-degree joint training opportunity of Tongji University and Hawaii University. Due to the wide distribution of residential areas and the irregularity of residential styles of Oahu region, Hawaii, the author will pick out two typical residential areas with the local characteristics of Hawaii as his research object. The author will analyze in detail the practices and processing methods of the planning and design of mountainous residential areas in Hawaii by means of the elements extracted from the investigation of two research subjects. The sample features are representative, typical and descriptive.

Fig. 6.1 Location of First Obect of the study
Source: *Author*

1. ***First object of the study***

The whole residential area is located in the southeast of Oahu, Hawaii, on Kahala Pacific street north of Kahala Mall; its terrain is a slope with an obvious contour difference; the building in the residential areas mostly

exist in forms of detached houses, each with its their own separate homestead and partition. It is a quite typical residential type in the mountainous areas of Hawaii; the households are completely detached from each other, with a spacious Mountain View and pleasant landscape. The entire area is intersected by Kahala Pacifica Street running in a north-south direction, high in the north and low in the south. There are 17 households in the whole area, with the gradually declining Kahala Pacifica Street running through from north to south. Studying the direction of the mountain and the shadows of the sun's rays, we can find that the whole area presents a climbing slope, characterized by an obvious difference in height and the features of the mountain.

2. ***Second object of the study***

The entire residential area is located in the southeast of Oahu, Hawaii, at the junction of Keanu Street north of Kahala Mall and Hunakai Street. The terrain is a slope with a little difference compared with the mountain; most buildings in the residential area exist in rows of semi-detached houses as well as blocks with semi- detached and detached houses mingled with each other, which is a quite typical residential style of residential areas on the mountain slopes in Hawaii. The households are relatively detached from each other; part of them integrate together by diaphragm walls, forming the same unit. This kind of combination smartly creates a sense of place in the residential area, forming a different residential pattern and environment different from the simple detached houses in mountainous areas. The entire area is connected in series

by an east-west parking space and public activity channel. There are 33 units in the area, arranged by the terrain in the north-south direction (high in the north and low in the south) for the row and west-east direction for the column. From the mountain direction of the map we can find that the whole area is relatively flat, forming the pattern of a residential block, characterized by relatively obvious mountains slopes.

Fig. 6.2 Location of Second Object of the study
Source: *Author*

6.2 The practices and characteristics of mountainous residential planning and design in Oahu region, Hawaii

This section will map and summarize the general practices and

characteristics of the planning and design of the mountainous residential region in Oahu district of Hawaii mainly by sampling and analyzing the first object's field research

Road networks

Kahala Pacifica Street, located on the north side of the main street -Malia Street, is a semi-enclosed hillside road, which starts from Malia Street, and ends at the mountain slope forest protection area line. Based on the hillside terrain, the road form is a climbing path along the hillside. Combined with the mountain terrain, which twists and turns along the trend of the slope, the road, which is about 6 meters in width, can afford three vehicles to pass through side by side at the same time.

The road is also the main road of the whole residential area, with its residences built on both sides. The householders need to drive from Malia Street to Kahala Pacifica, and go up the slope to reach their respective residences. The entrance or garage of each household is connected to Kahala Pacifa Street, some connected with it in the form of an area for public activities, constituting a transitional region. On both sides of the road are a pavement for pedestrians and a green belt respectively. The former is about 1 meter in width while the latter is about 0.5 meters in width, while the buildings are about 0.3 meters in height. The green belt separates the roadway and pedestrian trails distinctly, convenient for people to pass across it in different ways. In the mountain area, fishbone-like roads like this take advantage of the characteristics of the mountainous terrain effectively, linking all households of a variety of elevation together with great

facility and convenience.

Garages

Self-driving is among the most popular ways for Americans to travel, so the garage is a sign of an independent residential family. In the mountainous residential area of Hawaii, there are different types of garages between households: some garages are embedded into the houses in design, while others, which are partly open, occupy an area of its own. And the relationship between the garage and the main road is parallel and adjacent to each other. That is to say, every household's garage is at the same horizontal level with its driving-out road and adjacent to the residential entrance. This arrangement is very convenient for people living in the mountains to travel and to park their cars. In addition, due to the climbing trend of the mountain slope, all households in the residential area are of different heights, but the characteristics of the garages, which are placed parallel with and adjacent to the main road, will produce the illusion of "seeing only the garages but not the houses" as shown in Fig. 18: As the houses are below the terrain of the main road, the garages are arranged beside the main road, while an entrance to the downstream steps is usually placed next to it, and people usually enter their house is this way. Similarly, such scenes can also be see, namely, the house is built above the garage. As the house is above the terrain of the main road, the garage is arranged beside the main road. If so, an entrance to the upstream steps is placed next to it, and people usually enter their house is this way.

Fig. 6.3 Garage place and form
Source: *Author*

Residential Entrances

Constrained by the objective terrain conditions of Hawaii mountainous residences, the entrances to different houses also vary with the change of their concrete terrains. Influenced by the slope terrain, for some residences whose geographical locations are significantly higher or lower than the road (approximately one floor above or below the road), stairs about a person wide (about 0.8 meters) are usually placed as a residential entrance by the main road. The stairs are usually made up of several flights. Residential entrances like this are relatively small in scale, and the residential publicity and openness are

not conspicuous, for the house is relatively concealed. Some residences, which are relatively parallel to the main road, are geographically above it, so their entrances appear rather people-oriented, for they are often directly connected with the pedestrian trails of the main road. Besides, the courtyard space often serves as a transitional space at the entrance, connecting the house with the outside space. Although the residential entrances vary in forms as a result of their different geographical locations, they all have an identical particularity: that is, they are either adjacent to the garage or integrated into the garage as one. So, for those integrated into the garage, their entrances are handled in a relatively open way, and people can enter their houses quite directly, and their scale is relatively large. Its interaction with the external public space is rather strong.

Residential Courtyards

In the processing practice of the courtyard of every household in the mountainous residential areas of Hawaii, its main function is to be used as the transition space between the housing and the main road, namely the intermediate form of transitions of private space and public space, forming the spatial characteristics of vision-friendly type with the pedestrian line. Although the size of the courtyard of each household is limited by the nature of land use, and the openness of each household is different (Some courtyards are enclosed with low fences and steel wire fences, while others are completely open), but it is

clear that the practice is to enclose the house and put it in the middle of the block and take the courtyard as the invisible psychological protection space. Obviously, the common practice of the construction of residences in the mountainous areas in Hawaii is well worth reference in that they often enclose a residence with a residential courtyard and take it as the form of visual and psychological transition of private residential and public space to consider the relationship between the public and privacy of the independent residential area in the mountainous areas. On the one hand, this design effectively satisfies a household's need for a family courtyard in compact mountainous residential land use. On the other hand, it is also a good solution to handle the relationship between a household' privacy and sidewalks' publicity.

Disaster prevention and treatment

The disasters the ecological circles in the mountain areas are faced with affected by both human factors and natural factors, and with the special geographical features of mountainous areas, the threat of disaster is more serious than that in the plain areas. The natural disasters the ecological environment in the mountain areas faced with are mainly geological disasters such as landslides, mud flows, rock falls, avalanches, and floods. These problems mainly result from mountainous building activities. As natural terrain features are ignored when people dig out lots of earth or fill in lots of earth, forest vegetation is destroyed, and the man-made "mountainous plain" landscape has come into being, destroying the balance and stability of natural topographical features, changing the process of surface water circulation, and facilitating the occurrences of disasters. However, in

the Hawaii areas because of its own geographical conditions and the need for large-scale mountainous residential development, its preventive measures against natural disasters are also worth learning from. From the pictures, we can see the practices to handle landslides and mud flows in mountainous residential areas in Hawaii are as follows: 1.Grind and tamp the stones together to form a strong and solid platform. On the one hand, to prevent such disasters as landslides and mud flows as much as possible; on the other hand, to keep the original terrain and height of the mountain and make use of the existing materials of local conditions while meeting the residential construction as much as possible in order to minimize the impact of human factors on the original ecology. 2. Strengthen the protection of the original ecological environment in the mountainous region, plant green and retain the original vegetation and trees surrounding the mountainous residential areas to the best of our ability, in order to prevent the occurrences of mud flows, floods and other disasters caused by surface water circulations wash, erosion and migration.

Drainage treatment

The drainage treatment of the mountainous residential areas is the most important part of the sustainable design of the mountainous residences. Therefore, how to collect natural rainwater effectively and give it back to nature is the key to the sustainable development of mountain construction. The drainage treatment of mountainous residential areas in Hawaii is mainly carried out in two ways: 1. Every house discharges the natural rainwater into the courtyard or natural land through the roof drainage pipes in the form of a slope roof, and the

natural water resources are collected and used to protect the natural environment effectively. 2. On the pedestrian walkways of the public areas, outfalls are distributed in order to discharge the rainwater and surface water through the underground to the plains or the Pacific Ocean. On the one hand, this measure effectively prevents the possible cumulated water and floods caused by a heavy rain in the roads. On the other hand, it can also achieve the purpose of natural water circulation and strengthen the ecological construction of Hawaii mountainous areas.

Open design

As it is unavoidable for mountainous residences to contact the ecological environment in nature, they normally have a very good mountain view and a delightful environment. Therefore, in the mountainous residential construction in Hawaii, residential accessibility and openness in accordance with local conditions are also reflected in the interaction with the ecological environment of the mountain. 1. Public space processing between the residences. In order to maximize the utilization of land resources in mountainous areas, residences in mountainous areas in Hawaii are more likely to share the roadway and pavements for pedestrians as the main public space, so people are more likely to produce exchanges and other activities on the road. Of course, some residences are quite far away from the road, then at their entrances public space will be allocated for people to stop, stay and chat with convenience. In addition, some residential garages are slightly back behind public pedestrians' pavements, setting

aside a semi-public space for buffer action, play the role of transition between publicity and privacy. 2. Access facilities and open design of residences. Some mountainous residences are located on public roads (about one floor's distance), As vertical transportation (external stairs) is inconvenient and insecure, households usually construct a vertical elevator straight through the bedroom and living room along the supporting platform to enhance the physical accessibility of the residence in order to help the elderly and children to go upstairs and downstairs. In addition, as far as residences are concerned, in order to enhance the communications and eye contact of the people between the house and the ground road, households will normally prefer to live near the side of the road, and cooperate with the elevator and peripheral gallery to take the gray space as a medium of internal and external communications, which will indirectly enhance the possibility of eye contact and communication access in their residences.

6.3 The practice and characteristics of sloping land in Oahu District of Hawaii

The second research object is called Waialae Gardens, a sloping residential garden neighborhood mainly in the form of rows of semi-detached residential units; each unit is home to two to three households, and each household has two to three bedrooms. The case was first recorded in 1965, and every residential unit is a two-storey townhouse with an excellent view of the hills nearby and a broad skyline of sight. Besides, there is a six-storey apartment building, built on the terrain in the northeast corner (Unit No.: 4970), contains all of the units which take a bedroom of 624 square feet as standard. As the nature of this apartment in Hawaii hilly areas' residential research is not representative or universal, it is not included within the scope of this research. This section will map and summarize the general practices and characteristics of the planning and design of sloping land in Oahu District of Hawaii mainly through the sampling and analysis of the field research of the second research object.

Main roads and parking modes in residential areas

The location of this case is located in the gentle slope area or the junction of Hunakai Street, Keanu Street and Kilauea Avenue. (How steep is the slope?) Of them, Kilauea Avenue is the main mountain climbing road, and the highest of the three roads as well. Hunakai Street is a branch which connects the mountain climbing main road and the main roads, or secondary trunk roads, in urban areas. And Keanu Street is the link between the residential communities in this area, belonging to ordinary inner roads, whole level is relatively low. From

the plan of the neighborhood, we can see that the arrangement of the roads inside the areas is also very special. The entire community has two main entrances and exits, in the Keanu Street and Kilauea Avenue respectively, and connecting the two entrances is a roadway which can access both sides and also serves as a large parking lot, which is the core traffic area of the whole community as well as the largest public space activity area, as its form is arranged in parallel to the direction of the residential houses in the shape of a crescent moon; it is about 15 meters in width, while two private cars can go through in the middle of the road with parked cars on both sides near the residential location. As the parking lot spans widely, there are relatively more parking spaces. And in order to save space, the layout of parking spaces is also quite compact, and quite orderly. The pavement' space and the residential space of the community, which are located in the north and south sides of the parking area, are separated from the parking area of the public area by the arrangement of a belt of bushes almost as high as a person.

Layout characteristics of the townhouse

The whole residential area is divided by the shared large parking area into two parts, the south and the north. The residences are distributed in the form of the townhouse unit; altogether there are 33 household units, which can be divided further into two- household units and three-household units(That is, each townhouse unit has two to three sets of houses; the residential design of each unit is not the same, and two residential houses share the same gable). Residential

units are built on the basis of elevation of the gentle slope terrain, and each household enjoys an excellent view of the nearby hilly area. The apartments of a unit mainly face the north or the south, while the entrance of every household faces southeast. The pedestrian trails between households are mainly in the form of series which run through from west to east in the unit at the same elevation, and the units of different elevations connect the pavements from the north to the south. In addition, the private courtyard and the public garden space interconnect each other between the units, forming a well-proportioned, hierarchical layout feature of an organic ecological garden-style residential area.

The relationship between the road in the residential area, the public space and the private courtyard

The coherent flow line of the pedestrians' pavements connects the public spaces in the whole residential area, as well as the residential units and their private courtyards in series. From the residential area plan we can see that in order to save land resources, an internal residential trail is designed in a very simple way, for private and public trails are combined into one trail, distributed in residential units in the form of the branch mode, and the entrances of the unit residences at the same elevation are connected in series while the pedestrian trails of different elevations in the north-south direction to connect the steps are connected with the north-south pedestrians' pavement. Such a practice, on the one hand, is fast and convenient to realize the entry mode of different elevations; on the other hand, it can retain the original ecological

environment of the sloping lands as much as possible.

In addition, due to the terrain slope in the hilly slopes, settlements have four different elevations; residential units are distributed in different elevations, so there will different sizes of residential public spaces between the units according to residential arrangement: some large public spaces are equipped with tables and chairs and mail boxes, forming a recreational area, which is convenient for households to stay, talk and conduct activities; some smaller public spaces are mainly in the form of the front and back line of sight, forming the transition region between the units (Fig. 28). And there is no clear boundary between public spaces and private gardens, and they are distinguished only by different forms of green: covered with bushes, private courtyards, whose space for activities is limited, are chiefly distributed on the north of the residential units, playing the role of separation between the units, while the greening work of the public spaces mainly means growing soft grass and planting scattered coconut trees; clearly, its activity space is very spacious and open, and the line of sight and activity accessibility is high. The public space and the private residential courtyards are connected by means of green transition and shrub separation, which effectively distinguishes the different properties of space and integrates them into one naturally, forming a residential distribution model in an organic harmonious garden style.

Overall, because the terrain slope of the hilly areas is lower in the south and higher in the north, it is separated from the residential areas on both sides of the north and south as a large public space and a parking space through bushes some 1.8 meter tall. On the north side of the residential areas, adjacent to the bushes is the pedestrians' entrance trail, which is 0.6 meters wide, and the trail is

about 1.2 meters higher than the whole parking area, so when the residents go on the trail, they can have all the vision for the parking area. However, the relationship between the pedestrians' road, the public spaces and the private courtyard of the residential area, usually follows several patterns.

3. Adjacent to pedestrians' entrance trail are followed by the first base household model(private front courtyards, residential units, and private backyards), rammed earth retaining walls, the second base household model in turn upward.

4. Adjacent to pedestrians' entrance trail are public activity space, rammed earth retaining wall, and the second base household model(private front courtyard, residential unit, private backyard) in turn upward(one after the other as shown in the figure).

For the south side of the residential area, its slope is relatively flat. The relationship between the road in the residential area, the public space and the private courtyard is followed by the pattern as shown in Fig: Adjacent to the bush, the 0.6- meters-wide pedestrians' entrance trail is connected in turn with the first base household model (private front courtyard, residential unit, and private backyard), the second base household model. (Such an approach saves land)

Drainage and disaster prevention and treatment

In the gentle slope of garden residential areas, the practice of residential drainage is also very environmental-friendly. Because the houses of each

residential unit are pitched roof, so in the four corners of the eaves of each residential unit are respectively provided with a drainage tube straight through the ground surface. When a rainy season comes, pitched roofs will collect a lot of rain water and directly flow it down into the lawns, plants and trees of their private gardens, rendering it to the natural water cycle effectively in an environmental-friendly way. In addition, the backyard of each unit is equipped with bar-type sewers about 25 cm wide, in charge of rainwater retention in the courtyard of each residence in the stormy season, and the cumulated water will flow into the AlaWai Canal and the Pacific Ocean through the sewers, handling the problem of rain water and potential flood disasters with the least interference with the natural environment.

As for the prevention of landslides and treatment of mud flow disasters, the practice of hilly slope residential areas is consistent with the practice of mountainous residences. In this case, the planning of residential areas is divided into four different elevations because of the objective conditions of the sloping terrain and the topography. In order to make the residential units of each elevation a solid foundation, the approach is to grind the mountain stones and compact them together regularly in the foundation of each elevation, forming a stable solid sloping residential construction base. In addition, it is advisable to conduct the residential layout design as much as possible in accordance with the terrain of the original ecological system so as to reduce the soil erosion caused by the artificial factors (such as the excavation and filling) on the destruction of the natural environment which will bring the wash, erosion and migration of

the mountainous areas, preventing the occurrence of potential landslides and mud flow disasters.

CHAPTER 7 | PLANNING AND DESIGN OF MOUNTAINOUS RESTDENTIAL BUILDINGS IN FENGGANG TOWNSHIP

According to the viewpoints and conclusions of this thesis, the author will complete a residential planning and design of a certain mountain in China as an example. In order to better express the effectiveness of mountainous use and the overall design of mountain residential planning in this thesis, the author will apply the findings of this thesis to the selected the design site to complete a mountainous residential planning and design. The base site is located in a mountainous area of Fenggang County, Guizhou Province.

7.1 Site selection analysis

7.1.1 The province of the site

The base is located in Guizhou province, a mountainous province in Southwest China. Guizhou Province, whose capital city is Guiyang , is also known to the world as “Qián” or “Gui”for short; it is situated in the hinterland of Southwest China, bordering Chongqing, Sichuan, Hunan, Yunnan, and Guangxi on its four sides. Guizhou, a transportation hub in the Southwest Region, is a world-renowned mountain tourism destination and a main tourism province, a “national ecological conservation pilot zone”, as well as “an inland open economy pilot region.”

Guizhou’s terrain is low in the east and high in the west high, tilting from the center to the north, east and south sides; the province's landforms can be divided

into the four basic types, namely, plateaus, mountain areas, hills and basins. As it is mainly made up of plateaus and mountainous areas, it has long been known as “eight percent % of mountain areas, and one percent % of water and one percent % of land.” It is the only province without as any plain in China. With a subtropical humid climate, Guizhou has four distinctive seasons but with few seasonal changes. It is usually warm with an agreeable wind, and abundant rainfall. Its rain season is also in its hottest days. (Fig 7.1)

Fig. 7.1 Guizhou Location
Source: Author editing

Fenggang County is located in the northeast of Guizhou Province, bordering Si’nan, Meitan, Wuchuan and seven other counties; it is 224 kilometers away from Guiyang City, the provincial capital of Guizhou; it is 96 kilometers away from the city of Zunyi City; it is called the east gate of Zunyi; and both 326 National Highway and the Hangrui (Hangzhou - Ruili) Highway run through the county. The county has a total area of 1885.09 square kilometers, with a

jurisdiction over 9 towns, 5 townships, and 86 villages (or communities). As 326 National Road runs through the region, there is the central mountain county with a certain level of development. (Fig. 7.2)

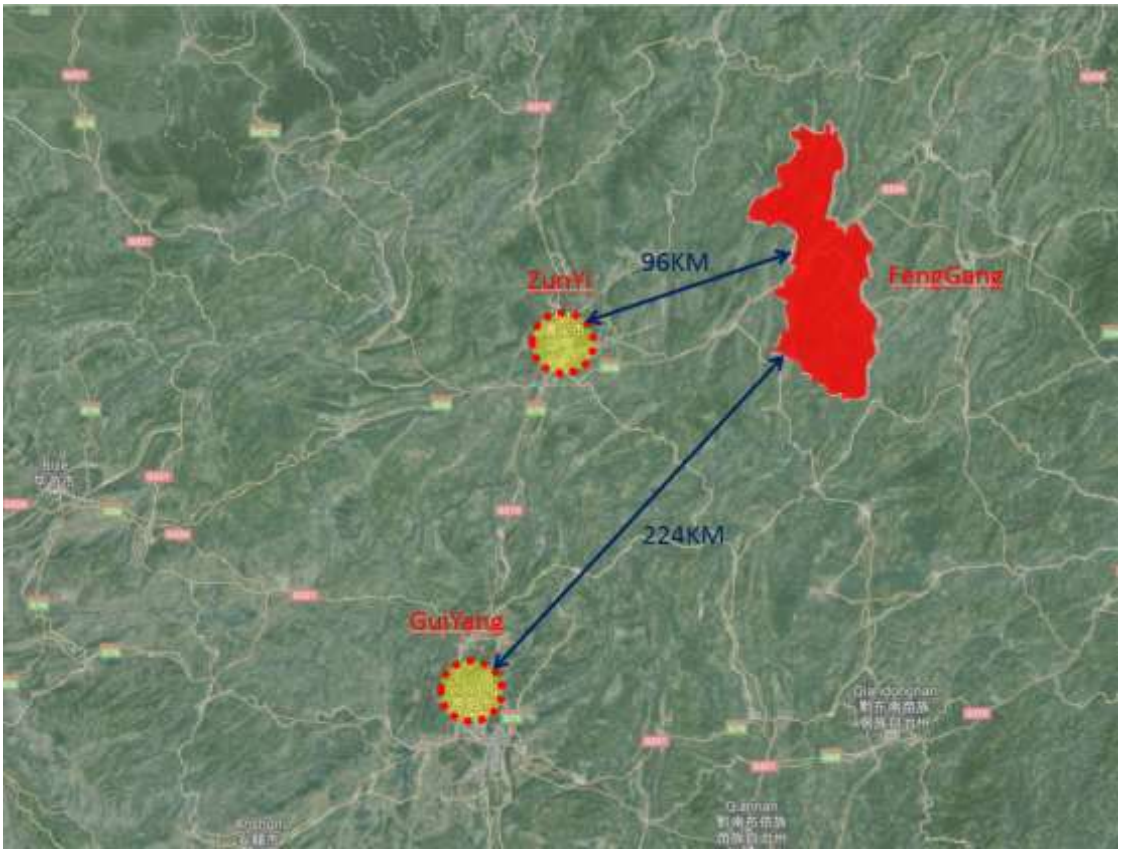

Fig. 7.2 Fenggang Location
Source: Author

7.1.2 Land resources survey

The land resources in Guizhou province are mainly mountains and hills. Its mountain area is 108,740 square kilometers, accounting for 61.7% of the total land area of Guizhou Province, while its hilly area is 54,197 square kilometers, accounting for 31.1% of the total land area of Guizhou Province. There are few land resources available for agricultural development, and the

area of cultivated land is shrinking due to the increase of population and the increase of non-agricultural land. (Fig. 7.3)

	Area	Proportion
Mountain Area	108740	61.7%
Sloping Hillside	54197	31.1%

Fig. 7.3 Land analysis
Source: Author

7.1.3 Regional overview about the Design Base

The design base is located in the southeast corner of the county seat, next to the G326 National Highway. The current situation of the base is mostly in a large number of farmland areas; in the project's base there are a number of hills, including several small gentle basin areas sandwiched in the middle. On the other side of the mountain are sparsely arranged some family cottages, belonging mainly to the farmers who cultivate farm labor all the year around. Through the display on Google Maps, the hills are covered with trees, in the shape of irregular arrangement; However, there are no trees in the mountain

basin. (Fig. 7.4)

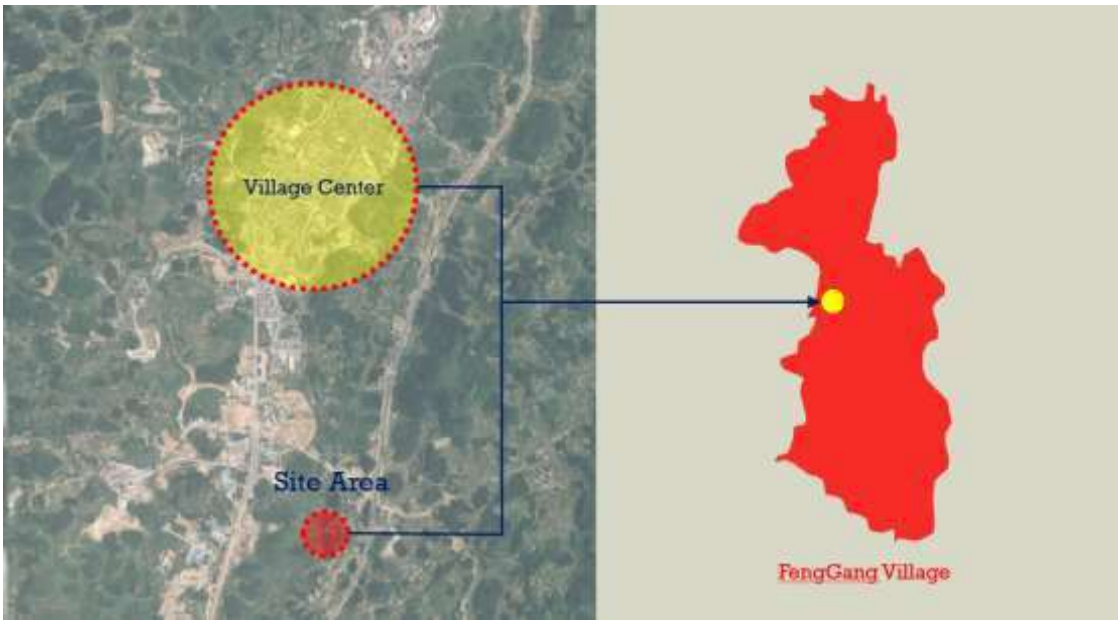

Fig. 7.4 Site Location
Source: Author

7.2 Design concept

The current status of domestic mountain dwellings mentioned in the previous chapters in this thesis are like this: in the urban areas, most are high-rise buildings and enclosed residential communities; in the rural areas, there is no effective land use and planning, so they are randomly distributed. In order to improve the present situation of mountainous residential development in our country, and to provide guidance and suggestions for the future development of

mountainous residential buildings in the next 50 years, this thesis provides a conceptual framework for the future of this project, namely low-rise independent residential unit layout mode.

Building type design

1. **Single-Family** House

Residential units imagine a family of 100 square meters of living space, divided into two storeys, each storey of 50 square meter covered by the slope roof to facilitate the collection of natural rainwater. Taking into account the design is to reflect the future development of mountain residential areas; the popularity of cars will be more extensive, so each family has a 4-meter-wide, 7-meter-deep garage and an independent backyard, which is separated from a 2.4-meter-high wall made of earth to prevent and avoid mountain landslides. (Fig. 7.5/7.6/7.7)

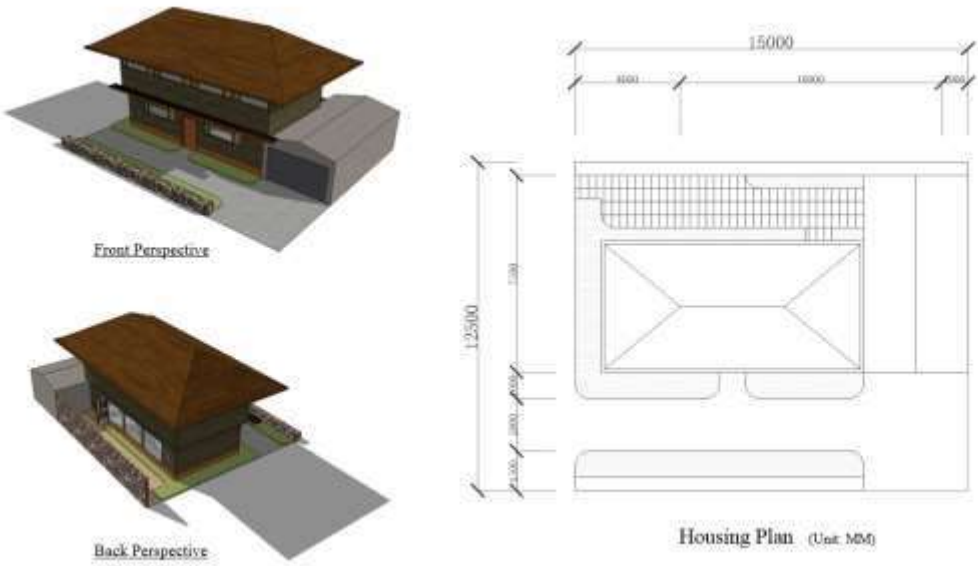

Fig. 7.5 Individual Building Plan

Source: Author

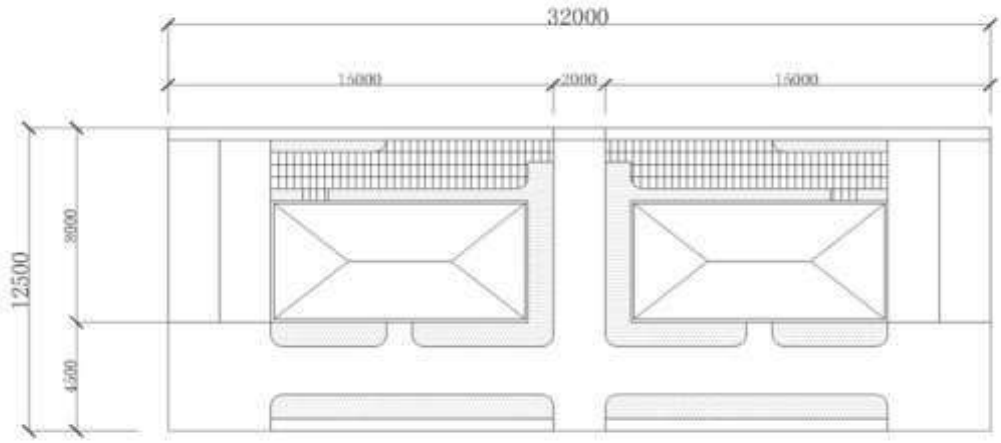

Fig. 7.6 Group housing plan
Source: Author

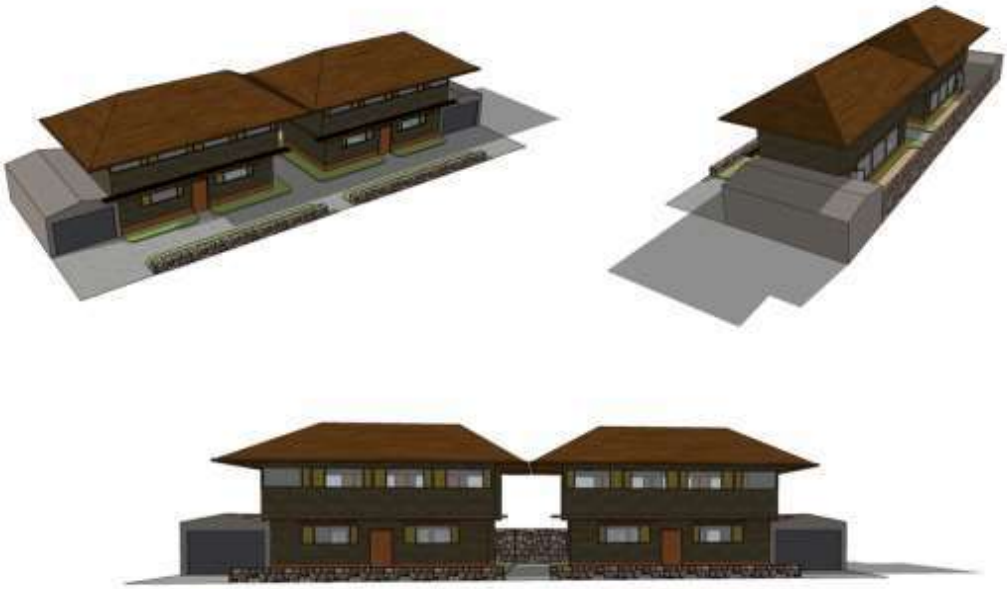

Fig. 7.7 Group housing perspective
Source: Author

2. Detached Group House

Detached group house type is divided into two parts. One is three houses; the other is two houses. Three-house type (Fig. 7.8) occupies the lot area of 510 square meters. Two-house type (Fig.7.9) occupies the lot area of 408 square meters. Each of them contains garages, which meet the needs of each family.

Fig. 7.8 Two house type

Source: Author

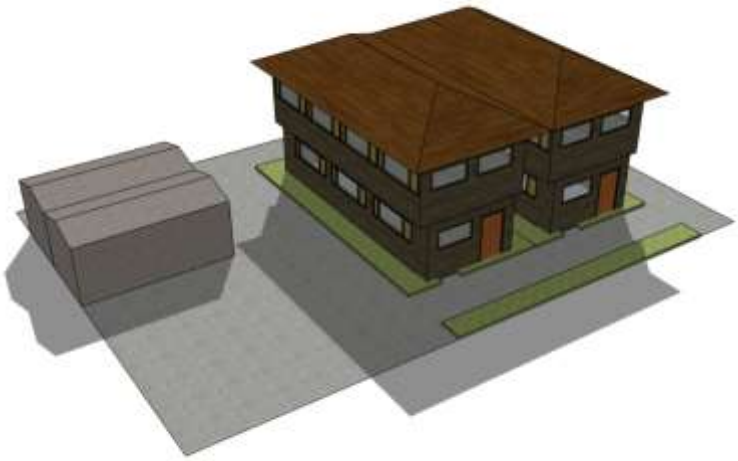

Fig. 7.9 Two house type

Source: Author

3.Five-Storey Middle rise

Five-storey middle rise (Fig. 7.10) contains a lot area of 196 square meters.

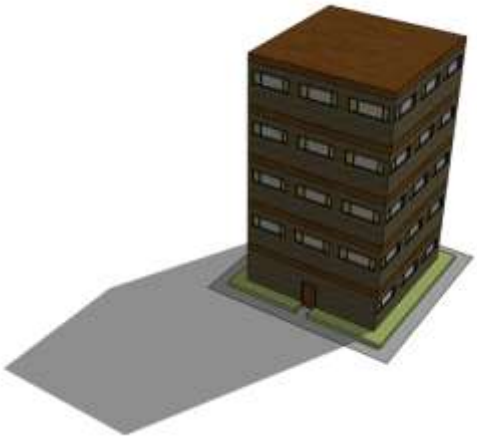

Fig. 7.10 Five-storey mid-rise

Source: Author

4. Four-Storey Apartment (Fig. 7.11)

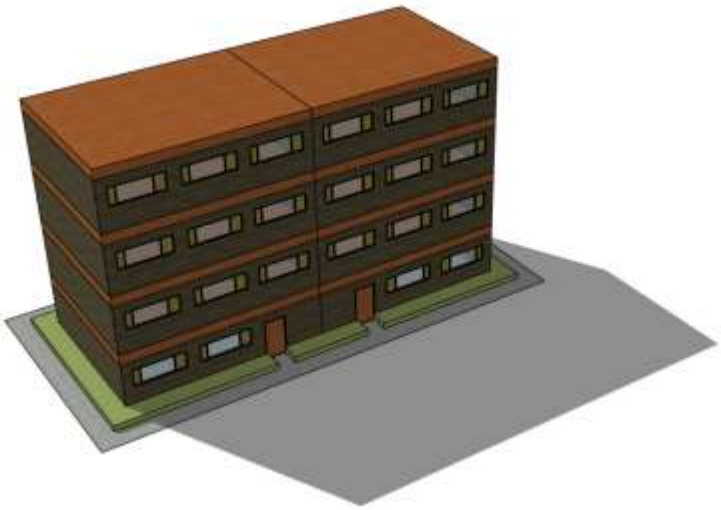

Fig. 7.11 Four-storey Apt.

Source: Author

Design area selection

Select the design base with the typical significance of the two hills as the main terrain conditions of the project design; on the left is the G326 National Road; the transportation is very convenient. In addition, in the design area, covering the plain area, gentle slope zone, mountain basin area, and the slope area of four different topographical features of regional conditions, also can reflect the overall situation of the reduction of the mountain in the planning and design.

Fig. 7.12 Design area

Source: Author

7.3 Design strategy

Overall layout

This design strategy in the overall layout complies with the compact arrangement between households and their neighbors, a distance of two meters to four meters distance as the two respective courtyard entrance channel; in the planning direction of the hillside, mainly based on the principle of the mountain on the potential, according to the elevation and the shape of the mountain, well-proportioned layout on both sides of the road. (Fig. 7.13)

Fig. 7.13 Design plan
Source: Author

Road transportation

Due to the convenient transportation provided by the National Highway on the left side of the design area, the design naturally brings an 8-meter-wide hillside main road from the National Highway area as the main access road to the hillside area. The purpose is to better connect the city main roads with residential roads, making the settlements and urban areas more accessible and the transportation more convenient. On the hillside, the road is mainly based on the mountain potential, according to the trend of the contours combined with the morphological arrangement of the overall layout, making the connection within the mountain area smoother. (Fig.14)

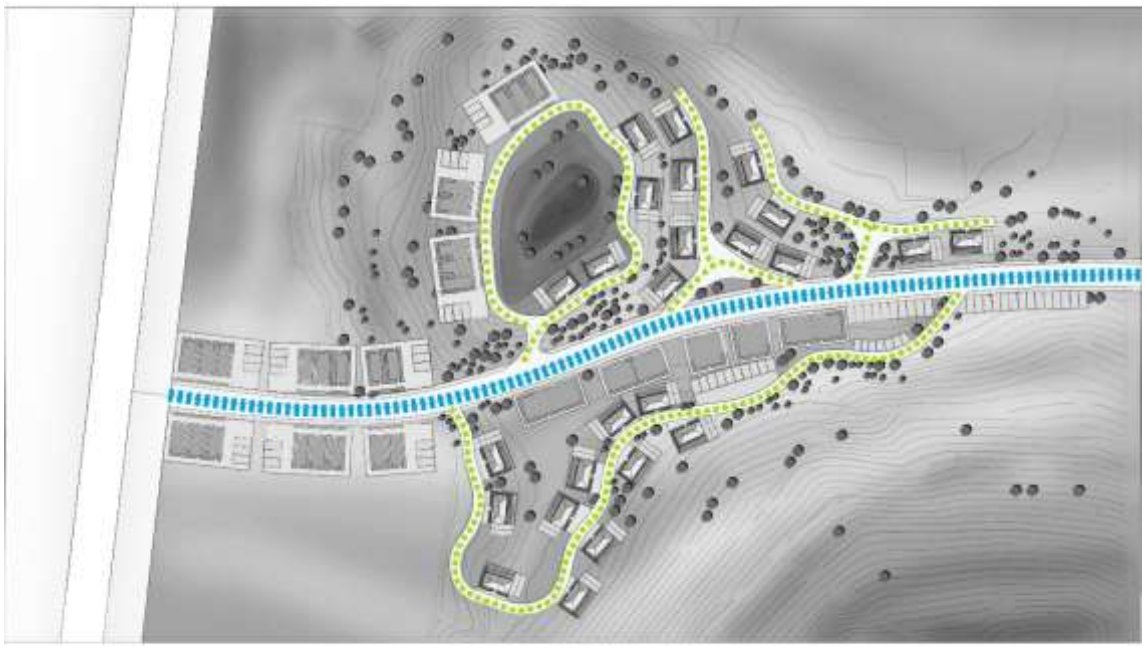

Fig. 7.14 Transportation
Source: Author

Planning section design

First of all, the design of the mountainous residence is in line with the principle of overall layout. Secondly, in the process of road planning, the main section is to ensure that the sight of the residents on the outside area is not blocked. In addition, the retaining wall in the backyard is also better to maintain the mountain landscape, to prevent the occurrence of disasters. (Fig.15/Fig.16)

Fig. 7.15 Section Mode I
Source: Author

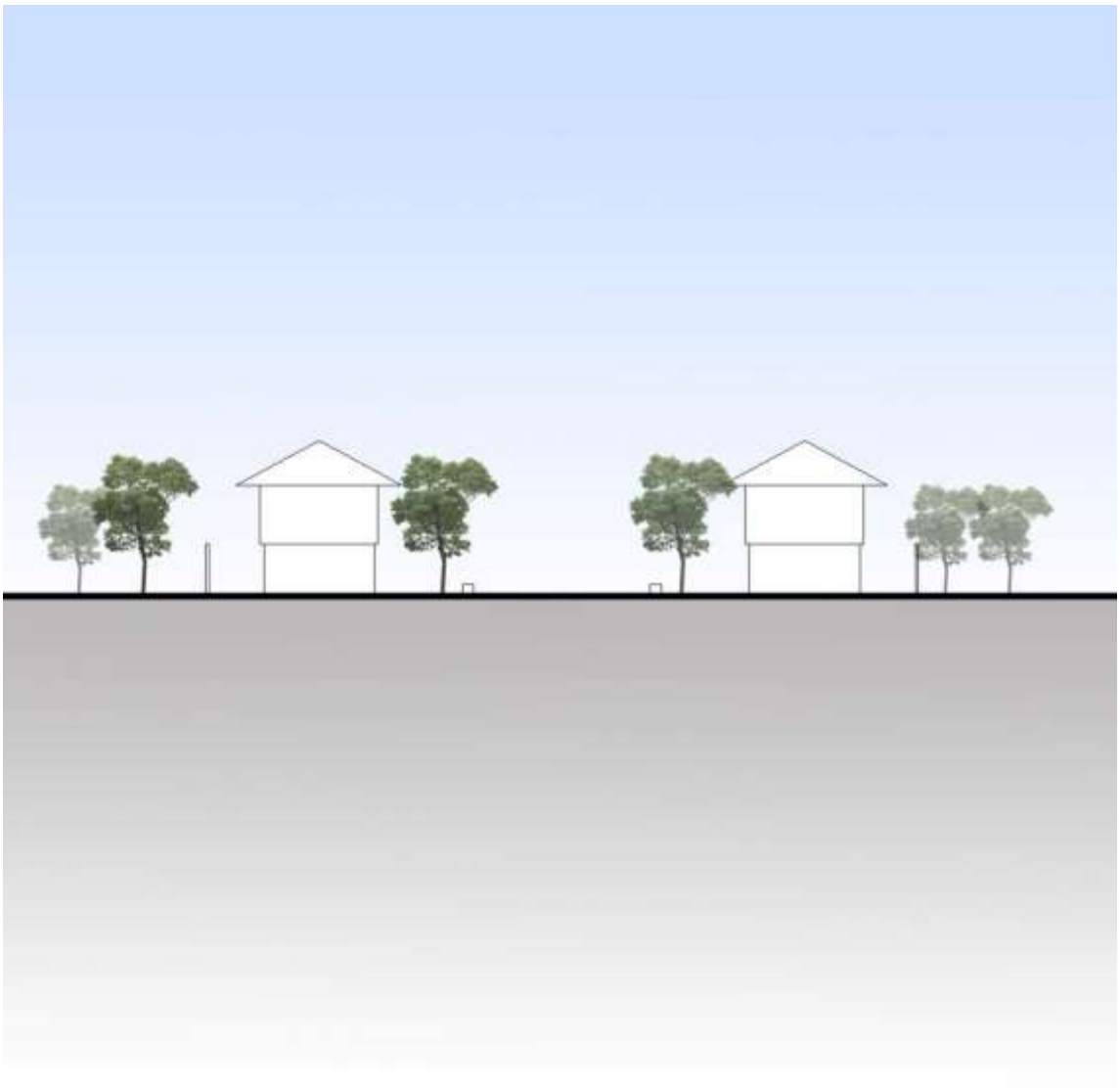

Fig. 7.16 Section Mode II
Source: Author

Drainage and power supply

In terms of drainage, the design will arrange the layout of the ground drains in the mountain road and the secondary road, leading to the underground drains. And in terms of power supply, on both sides of the road will set the telegraph poles and cable conductors, which leads the cable to the households in the mountain. (Fig. 7.17/7.18)

Fig. 7.17 Drainage system
Source: Author

Fig. 7.18 Electricity system
Source: Author

Rendering（Fig.19-25）

Fig. 7.19
Perspective 1
Source: Author

Fig. 7.20
Perspective 2
Source: Author

Fig. 7.21 Perspective 3
Source: Author

Fig. 7.22
Perspective 4
Source: Author

Fig. 7.23 Perspective 5
Source: Author

Fig. 7.24 Perspective 6
Source: Author

Fig. 7.25 Perspective 7
Source: Author

7.4 Design summary

This design mainly aims at the present situation of domestic mountain residential areas, and provides some innovative creation and transformation program for current domestic mountain residential planning and design. Based on the background of mountain regions of Fenggang Town, Guizhou Province, this thesis discusses and studies the planning and design of mountainous residences from the overall layout, road transportation, planning section design, drainage and power supply infrastructure projects in the four mountain features, the plain areas, the mountain slope areas, mountain basin areas, and hilly areas in the region,

The main purpose of this project is to improve the existing conditions in the mountainous housing in China, and make the road development as the main line, according to local conditions for the design purpose, put forward the feasible future in the light of its general trend of low-rise, low-density mountainous residences and residential areas in the direction of development, and advocate the effective use of mountains, increase the possibility of exploitation and utilization of mountain resources, bringing about constructive ideas for future development of residential planning in mountainous areas in china.

CHAPTER 8 | CONCLUSION AND PROSPECTS

As one of the geographical features people's life depends on, mountainous areas, ever since ancient times, have been playing a very important role in people's living activities. Since ancient times, the development on the mountainous residences inside and outside China has always been an issue worthy of study, which involves the use of land, the development of mountainous areas, and the adaptability of human residences and so on. In recent years, due to the shortage of land resources, the rapid development of urban development makes people pay more attention to the construction of mountainous housing and mountainous utilization, whereas the planning and development of mountain residences is also one of the most important subjects in the study of architectural design and urban planning in recent years.

Based on the perspective of sustainable development, this thesis chooses the development of mountainous houses in our country and the Hawaiian islands (the United States) as the object of research, examines and compares the historical development of the mountainous residences between them and the characteristics and practices of today's planning and design, and draws some conclusions of the proposed planning and design of today's domestic mountain residential sustainable development.

In the third chapter, this thesis discusses the historical development and land use in Hawaii and China's mountain slopes before the emergence of motorized vehicles, studies and compares the similarities and differences between

the two in their respective development processes. In the fourth chapter, this thesis mainly discusses the status of development of contemporary planning and land use in Hawaii and China's mountain slopes after the emergence of motorized vehicles, studies and compares the differences in planning and development, especially in the integrity of the relationship between the development of roads and regional development, so that based on the case study, this thesis puts forward some suggestions on how to improve the planning and design of mountainous residential development in China. In the fifth chapter, this thesis mainly makes a comparative study of the difference between the two in the development of norms based on residential design specifications and mountain residential classification in Hawaii and China.

In addition, one fact should not be neglected. Nowadays, more and more families have private vehicles in Hawaii as well as in Chongqing, China. According to the statistics from Profile of Selected Housing Characteristics (2000), almost 90% families have private cars by themselves, among of which 16.3% has three or more cars. In Chongqing China, the statistics shows that there is 132 vehicles per 1000 persons, higher than Hong Kong and Shanghai. In that case, vehicle transportation is getting more influential on the residents and residences; for the future mountainous areas, we need to get more focus on how to deal with the relationship between residences and private vehicles, and need to take private transpiration into consideration.

Fig. 8.1 Private Vehicle Proportion

Source: Profile of Selected Housing Characteristics (2000)

According to the comparative analysis of the two main research objects, this thesis make the following tentative conclusions and suggestions for the planning and development of mountainous residential areas and land use in China by using the planning and development of mountainous residential in Hawaii as a reference:

1. We should seek to change mountain land use patterns fundamentally. As today's mountain cities' residences and residential areas are pursuing the maximization of the benefits and the speed in land use, and imitating the land use patterns of plains, mountain areas are mistakenly treated as plains and as a consequence, a great waste of land resources follows. Therefore, the author of the present thesis proposes that the land use patterns of the mountainous areas in Hawaii should be studied closely to promote the overall development of mountain roads along with the development of motorized transportation and to develop the mountainous living space in a way that extends the road as a whole.

2. We should seek a breakthrough in residences and residential patterns, in line with China's national conditions of course. At present, mountainous

residential planning and development in our country is divided into mountain residences in the mountain city and mountain residences in rural villages and towns. Comparatively speaking, the degree of residential planning in urban mountainous residences, which is higher than village mountain residences, has some laws and characteristics to follow, but their problems and shortcomings are also very obvious. The mountainous houses in the city are mostly enclosed residential areas with high-density, high-rise residences as the main residences and the main model, which also agrees with the characteristics of the urban population as described above for the pattern of land use——digging extensively and filling extensively to accommodate more people in the city within a short period of time.

As for rural residential areas, the lack of planning for land use results in irregular modes of residences and the waste of land resources. The Hawaii mountainous residences and residential patterns are mainly low-rise detached houses, with the layout based on single-family ownership of land and a courtyard; on the plains, there are more high-rise apartment-style residences, which tend to extend beside and along their respective mountain roads. Such characteristic approaches could be used for reference, for their effective development of mountainous areas to increase the mountain living space, minimizing the destruction of natural environment, so that the sustainable development of mountainous residential development model will be achieved. At the same time, we should pay attention to the mountain state of some mountainous cities in our country, and make rational development and efficient arrangement.

3. Subdivision of mountainous residential land classification should be concretized. At present, there are only some general guidelines of division in our country, but no specific details to the mountain residential planning in the classification of residential land, whereas there is a detailed division of the classification of land for mountainous houses in the Hawaiian region, which has subdivided its residential land into five categories according to the size of the land. Such an approach allows for more detailed planning and utilization of land, and delineates each household's own area.

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APPENDIX

1902 HAWAII TERRITORY SURVEY Oahu Maps
Source: Hamilton Library, UHM

1912 HAWAIIAN ISLANDS MAP_HONOLULU
Source: Hamilton Library, UHM

1933 HAWAII DEVELOPMENT MAP_HONOLULU
Source: Hamilton Library, UHM

1953 HAWAII DEVELOPMENT MAP_HONOLULU
Source: Hamilton Library, UHM

1998 HAWAII DEVELOPMENT MAP_HONOLULU
Source: Hamilton Library, UHM